About the cover

The cover picture shows the remarkable effects caused by the dramatic drop in temperature following an intense surge of the winter monsoon on 27th December, 1991. The picture was taken at Tai Mo Shan where temperatures dropped to a low of -4.7°C. More details on the cold spell can be found in the article by Peart & Guan in this issue.

(cover picture courtesy of Oriental Daily News)
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Editorial

This issue of the Bulletin is published shortly after the United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil from 1st to 12th June. It is not altogether surprising that much of the subject matter is on topics related to Climate Change. This is appropriate, not only because of the major focus that has been directed towards anthropic change in the past few years, but also because of the unusual weather conditions which have characterized Hong Kong for the past six months.

In a paper on Future Sea-level Rise and Coastal Land Reclamations for Urbanization in Hong Kong W.W.S. Yim examines in more detail one of the issues raised by G. McGregor in his paper Climate Change and Hong Kong: Possible Implications and Responses published in the previous issue of the Bulletin (Vol. 2, No. 1, Special Issue on Climate Change). Given the major coastal land reclamations associated with the Port and Airport Development Strategy (PADS) it is timely to assess the threat, if any, of future sea-level rise on such extensive reclamations.

Returning to the topic of unusual weather a brief glance at the Hong Kong Weather Reviews for Winter 1991/92 and Spring 1992 in this issue will confirm that the past half year has indeed been unusual. Following on the heels of one of the warmest Christmas Days ever in Hong Kong the mercury plunged only a few days later under an icy blast of the winter monsoon to produce the second lowest temperature recorded in December and spectacular ice and frost on high ground. This unusual cold spell is the subject of a paper A Cold Spell in Hong Kong by M.R. Peart and Dongsheng Guan. With the development of a strong El Nino in the South Pacific the remainder of the winter and spring 1992 was uncommonly wet with many records being broken, perhaps most notably the record hourly rainfall on 8th May. Whether or not there are teleconnections linking El Nino and perhaps the eruption last summer of Mt. Pinatubo to these events remains to be seen when all the data have been assessed.

Still on the theme of Climate Change three items have been included in News and Announcements which are timely. The first concerns details of a CD-ROM which consolidates selected data sets useful in the analysis of global climate change. This is available internationally to promote further research. The second is a transcript of a NASA Press Release on the End of Mission Statement of the Second Airborne Arctic Stratospheric Expedition (AASE-II) dealing with atmospheric chemistry and ozone depletion in the Northern Hemisphere. The third is a transcript of an NSF Press Release summarizing new findings from study of ocean-bottom cores which provides new evidence for sudden global climatic change.

Finally, a major part of this Bulletin has been used to provide readers with Issue 5 of Tiempo: A Bulletin on Global Warming and the Third World. This is published by the International Institute for Environment and Development in London and the University of East Anglia in Norwich, U.K. It features articles and information of relevance to research and policy-making in a world where global warming is an increasingly realistic future scenario.

All of the aforementioned articles have been received via electronic mail lists on the Internet and are included here for the information of readers who may not have access to such sources. The Editorial Board would be pleased to hear whether or not readers find them useful and informative so that we can make a decision on whether or not to continue dissemination in future issues of the Bulletin. Your feedback is required to help us make a decision.

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Future sea-level rise and coastal land reclamations for urbanization in Hong Kong *

ABSTRACT

Data collected from tide gauge stations located on coastal land reclamations in Hong Kong are found to be unreliable for indicating the local rate of future sea-level rise or fall unless long-term ground settlement and crustal movement are taken into account. Because of this, tide gauge stations should be monitored for ground movement on an annual basis using state-of-the-art surveying methods including satellite radar altimetry.

For reducing the risk of flooding, the formation level of reclamations must take into account the rate of future sea-level rise, the amount of ground settlement, past storm surge levels and past rainstorm flood levels. Because allowances for long-term ground settlement have been insufficient in the past, reclamations affected by large post-constructional settlement are facing a high risk of inundation during storm surges and rainstorms.

Introduction

Estimates based on the global rise of sea level over the past century have been used for predicting the rate of future sea-level rise by Gornitz et al. (1982), Hoffmann (1984) and others. However, much closer scrutiny and study are needed if fundamental planning errors based on assumptions are to be prevented (Belperio, 1989). Because there is no global synchronism in eustasy (Morner, 1983), it is of utmost importance to determine the rate of sea-level rise for any area based on local data. In this paper the evidence for relative future sea-level change and how it affects coastal land reclamations in Hong Kong is presented. The main objective is to provide information to assist planners and other decision makers to enable them to take correct action.

Hong Kong, with a population of about 5.7 million and the second largest port in the world in terms of container traffic after Singapore, is situated near to the mouth of the Pearl River Estuary (Figure 1). An estimated 5 percent of its total land area has been created in the past through coastal land reclamation from the sea. Since the middle of the nineteenth century there has been a dramatic shift of the coastline in Victoria Harbour (Figure 2) around which approximately 65 percent of the present day population is distributed.

The main factors causing an increase in demand for coastal land reclamations are:

(1) the rapid population growth particularly since the end of the Second World War;
(2) the shortage of naturally flat land for agricultural activities;
(3) the shortage of naturally flat land for urbanization and related activities;
(4) the threat of disastrous landslides when building on steep slopes;
(5) the transfer of sovereignty to the People's Republic of China in 1997.

Figure 1  Location map of tide gauge stations, reclamations and New Towns involving coastal reclamation in Hong Kong.

Figure 2  Coastal land reclamations in Victoria Harbour, Hong Kong (after Stoner, 1989).
Consequently, major infrastructural developments are scheduled for completion by 1997 and beyond in order to stimulate economic growth and to boost the confidence of Hong Kong people.

Major schemes of coastal land reclamation are currently being planned under the Port and Airport Development Strategy (PADS) of the Hong Kong Government including the major construction of a replacement international airport and new port facilities. The total capital expenditure for these works is estimated at over US$ 1.6 billion. In view of the ambitious coastal development planned, it is essential to determine whether the threat of future sea-level rise on the relocations is real.

Coastal Land Reclamations

An account of the coastal land reclamations in Hong Kong has been given by McFeat-Smith et al. (1989). Large ground-surface settlements are known to have occurred in these reclamations as the result of consolidation of marine clay layers where they have not been removed by dredging (see Foott et al., 1987). It is not uncommon for a 10 metre thick marine clay layer to take four years to achieve 95 percent consolidation, including 1.6 metres initial compression (McFeat-Smith et al., 1989). Although engineering solutions involving dynamic compaction, sand dredging and surcharging are often employed during the construction period, long-term post-constructional ground settlement has been detected in the past through surveying checks of benchmarks located on reclamations (M.T. V, Tong, personal communication). It is therefore possible for ground settlement to be misinterpreted as sea-level rise, and, it is necessary to quantify the rate of ground settlement to assist the estimation of the rate of sea-level change.

Analysis of Temperature Records

Global warming attributable to the greenhouse effect is not supported by temperature records either in Hong Kong or in its neighbouring city, Macau, over the past one hundred years. In an analysis of secular trends in urban temperature in Hong Kong, Koo (1990) found that the increase in running mean temperatures of the Hong Kong urban station of about 0.7 °C during the past century is best explained by the urban heat-island effect. A measuring station located on Waglan (Figure 1), a remote outlying island away from the urban areas of Hong Kong, failed to show any definite temperature rise during the past twenty years. On the other hand, the Macau urban station which is located near the southern limit of the Pearl River Delta about 40 kilometres to the west of Hong Kong, was found to show a marginal decline in running mean temperatures over the past century. This difference found between the two urban stations may be explained by the enclosed nature of Victoria Harbour which is less favourable for the dissipation of heat arising from the urbanization process.

Measurements from Tide Gauges

There are at present nine tide gauges operating in Hong Kong (Figure 1). The oldest station, North Point, has been in operation since 1952 but was relocated to Quarry Bay in 1986. However, because these two stations are less than one kilometre apart, tide gauge data collected at Quarry Bay is used as part of a continuous series.

The uncorrected mean annual sea level at North point during the period from 1957 to 1988 is shown in Figure 3. A rising trend is indicated by the five-year running mean, and, from 1971 onwards, a positive deviation from the mean is discernible. This is in general agreement with the conclusions of Yim (1992) who found a mean rate of sea-level rise of about 40 centimetres per century based on a graphical method of plotting the 1962-1986 mean annual sea level data. However, since both the North Point and Quarry Bay tide gauge stations are located on sea walls of land reclamations, ground settlement is probable (Yim, 1988). When the mean annual sea level is corrected for ground settlement determined by surveying the elevation of tide gauges to nearby benchmarks, a decline in the five-year running mean is observed (Figure 4). Therefore, if the amount of ground settlement measured is real, it is possible that there has been a relative sea-level fall in Hong Kong caused by local uplift. Doubts on the stability of benchmarks used for checking also exists because they are likewise located on reclamations and are similarly affected by ground settlement. Consequently, there is uncertainty over the tide gauge record at North Point as to whether it is indicative of a rising or falling sea-level trend.

A comparison has been made between the uncorrected mean annual sea level at the three tide gauge stations with the longest uninterrupted record in Hong Kong. These stations are at Chi Ma Wan, North Point and Tai Po Kau and the results of the comparison for the period from 1970 to 1986 are shown in Figure 5. As can be
Figure 3 Uncorrected mean annual sea level at North Point during 1957-1988 with data from 1986 based on Quarry Bay tide gauge (redrawn from R. Wardlaw, personal communication).

Figure 4 Corrected mean annual sea level at North Point during 1957-1988 with data since 1986 based on Quarry Bay tide gauge (redrawn from R. Wardlaw, personal communication).
Figure 5 Uncorrected mean annual sea level at Chi Ma Wan, North Point and Tai Po Kau tide gauge stations during 1970-1986 with North Point data since 1986 based on Quarry Bay tide gauge. Chart datum is approximately 1.3 m below mean sea level.

seen both the Chi Ma Wan and Tai Po Kau tide gauge stations show a declining trend which is in agreement with North Point after correction for ground settlement (Figure 4). Therefore uplift of the Hong Kong region as a whole is probable. Because of this possibility it is desirable to carry out geodetic surveying in the future to permit assessment of ground stability at these tide gauge stations.

Seismological Evidence for Crustal Movement

In addition to tide gauge measurements, evidence for local crustal movement is available through the seismograph network established by the Royal Observatory, Hong Kong in 1979. Minor local earthquakes felt by residents but below a Richter magnitude of 2 are known in Hong Kong. For example, three were reported and discussed in Poon (1985). Such events may account for the uplift indicated by the record of tide gauges in addition to causing ground subsidence in reclamations.

Although a large proportion of microseismic events in Hong Kong are likely to be man-induced as a consequence of blasting in quarries, rock slopes and tunnels, it is also conceivable that some are natural. The latter may be accounted for by the southerly migration of the Pearl River Delta causing loading on the crust and triggering off earthquakes. This argument is supported by two lines of evidence. First, the Pearl River is discharging a considerable amount of suspended sediment load which has been estimated at 8,336 x 10^6 tons annually (Ren, 1986). Secondly, both uplift and subsidence were identified within the delta region by means of radiocarbon dating (Huang et al., 1984). The net effect of crustal movements on sea levels in the Hong Kong area is, however, poorly understood. In an assessment of the geological factors influencing seismicity in Southern China by Lee (1981) it was suggested that Hong Kong lies within a weak local rift system. Based on this assessment, both tectonically-induced uplift and subsidence may only have a minor effect on sea levels.

Possible local uplift and subsidence are indicated by the record of the Macau-Siac tide gauge station at Macau. From 1925-1974 this station was located on granitic bedrock where ground surface settlement may be safely ruled out. However, in 1975 it was moved to a land reclamation site. The mean annual sea-level trend during the period from 1925-1974 is shown in Figure 6. A sharp fall followed by a rise in mean annual sea level is evident during the period 1960-1963 and 1972-1974 respectively. Although it is dangerous to link these events to a single cause due to the complexity of the factors involved in determining sea level elevations, two factors, earthquakes and rainfall, are particularly attractive as sources of explanation.

Two major earthquakes with a Richter magnitude exceeding 6, and located along a major northeast-southwest trending fault passing immediately to the north of Macau, have been recorded within a radius of 250 kilometres of Hong Kong (Lee, 1981). They occurred at Heyuan on 19th March, 1962 (M = 6.1) and at Yangjiang on 26th July, 1969 (M = 6.4). Both coincide well with the changes in the tide gauge record at Macau-Siac.

On the other hand, the annual rainfall recorded at the Royal Observatory station during 1963 was the lowest since instrumental records began while
both 1972 and 1973 were consecutive years with rainfall well above the mean ranking eight and second highest on record respectively. Since rainfall is associated with depressions and rainfall intensity in Southern China exerts influence on the estimated mean annual runoff of $3.4 \times 10^8$ m$^3$ (Ren, 1986) from the Pearl River, sea-level elevations would likely be affected. Without further investigation, however, it is not possible at this time to quantify the relative contributions due to earthquake activity and variations in annual rainfall intensity.

Analysis of Storm Surge Record

Hong Kong is influenced during the summer and autumn by extreme sea levels associated with tropical cyclones known locally as typhoons. Some attention in the past has been devoted to the formation level of land reclamations with adequate protection from storm surges and rainstorm floods. Consequently, the land reclamations are already protected from a gradual rise in future sea level even though the stability of the ground is in doubt because of ground settlement.

A summary table of meteorological data and maximum sea levels associated with major tropical cyclones in Hong Kong from 1937 to the present is shown in Table 1. It can be seen that the maximum sea levels recorded at the North Point, Chi Ma Wan and Tai Po Kau tide gauge stations are not consistent with each other. The difference found is attributed mainly to the location of the stations in relation to the coastal configuration and the track of the typhoons (Yim, 1992). Tai Po Kau, for example, is located in the nearly land-locked Tolo Harbour with only a narrow seaward opening to the northeast (Figure 1). Thus, it is likely that the highest maximum sea level recorded at this site is due to seiching induced by the Coriolis force. In contrast, Victoria Harbour in which North Point is located, has lower maximum sea levels because it is open both at its eastern and western ends (Figure 1). The highest sea levels in Hong Kong are also found to be associated with cyclones entering the South China Sea via the Luzon Strait where they have little interruption in their forward momentum.

In terms of casualties, storm surges are by far the worst type of natural hazards in Hong Kong. Two typhoons, one in 1906 and the other in 1937, which were both accompanied by severe storm surges are documented to have estimated death toll of 10,000 or more. Since the majority
Table 1 Summary of meteorological data and maximum sea level of major typhoons in Hong Kong since 1937 (based mainly on Chan, 1983). Chart datum is approximately 1.3 m below mean sea level.

<table>
<thead>
<tr>
<th>Tropical cyclone</th>
<th>Year</th>
<th>Maximum Central Movement</th>
<th>Maximum sea level in m above chart datum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>gust in knots</td>
<td>MSL pressure in hPa</td>
</tr>
<tr>
<td>Unnamed</td>
<td>1937</td>
<td>130°</td>
<td>949</td>
</tr>
<tr>
<td>Mary</td>
<td>1960</td>
<td>103</td>
<td>966°</td>
</tr>
<tr>
<td>Wanda</td>
<td>1962</td>
<td>140</td>
<td>944°</td>
</tr>
<tr>
<td>Ruby</td>
<td>1964</td>
<td>122</td>
<td>954°</td>
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<tr>
<td>Dot</td>
<td>1964</td>
<td>94</td>
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<td>Rose</td>
<td>1971</td>
<td>121</td>
<td>982</td>
</tr>
<tr>
<td>Hope</td>
<td>1979</td>
<td>94</td>
<td>950</td>
</tr>
<tr>
<td>Ellen</td>
<td>1983</td>
<td>128</td>
<td>960</td>
</tr>
</tbody>
</table>

*Estimated

of typhoons are invariably associated with heavy rainfall, their impact is in reality a combination of storm surge and rainfall runoff flooding. In comparison to a gradual rise in sea level, typhoons and the associated storm surges and heavy rainfall are potentially more threatening and are consequently of greater concern. However, an examination of the annual total number of cyclones entering the South China Sea between 1946 and 1989 failed to show any increase in frequency.

Future Coastal Development

Based on the evaluation of local evidence it seems that future coastal development must take into account the following factors:

1. the rate of future sea-level change;
2. the amount of ground-surface settlement;
3. past storm surge levels;
4. past rainstorm flood levels.

For facilitating the estimation of (1) and (2), it is necessary that long-term ground settlement monitoring be carried out on all coastal land reclamation. Two possible methods are suggested here. First, benchmarks and tide gauge stations on reclamation should be checked annually using state-of-the-art surveying methods against the nearest benchmarks located on bedrock sites. Secondly, satellite radar altimetry (illustrated in Figure 7) should be used annually to measure geoidal changes caused by crustal movement.

In order to reduce the threat of storm surge flooding, the existing practice of adopting return periods of maximum sea levels as the formation

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Return periods of maximum sea level in metres above chart datum estimated using Gumbel's method (after Chan, 1983).

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<tbody>
<tr>
<td>10</td>
<td>3.34</td>
<td>4.13</td>
<td>3.40</td>
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<tr>
<td>50</td>
<td>3.71</td>
<td>5.01</td>
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<tr>
<td>100</td>
<td>3.86</td>
<td>5.39</td>
<td>3.89</td>
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<tr>
<td>200</td>
<td>4.01</td>
<td>5.76</td>
<td>4.03</td>
</tr>
<tr>
<td>500</td>
<td>4.22</td>
<td>6.25</td>
<td>4.22</td>
</tr>
<tr>
<td>1000</td>
<td>4.37</td>
<td>6.62</td>
<td>4.37</td>
</tr>
</tbody>
</table>

level of reclamations should be even more conservative. Many old reclamations in Hong Kong are based on adopting a return period of 200 years (Table 2), the value used being a compromise between storm surge and rainstorm flood levels. Consequently, the formation level does not offer protection against the higher storm surges. If the reclamations are to be protected from flood damage the possible options are:

1. construction of high dykes to protect reclamations from being overtopped;
2. the topping up of low-lying areas prone to flooding particularly during urban renewal programmes;
3. the use of urban planning to zone land uses according to their tolerance to flood damage;
4. the installation of flood pumping stations in important development areas.

Out of these options, (4) is likely to be effective for rainstorm flooding only. As a preventive measure against storm surge flooding, high dykes appear to be the most cost-effective means to protect the important development areas for the simple reason that they cause the least disturbance to the existing land use.

Conclusions

No conclusive evidence has been found to show that the sea level has been rising in Hong Kong during the period for which tide gauge records are available. The analysis of data collected from tide gauges was found to indicate a slight decline in sea level when a correction for ground-surface settlement is made. Such a relative decline in sea level may be mis-interpreted as an apparent sea-level rise because tide gauge stations located on coastal land reclamations may be subsiding at a rate faster than the rate of sea-level fall. Therefore it is recommended that all tide gauge stations located on coastal land reclamations be checked for ground settlement annually by surveying to bedrock benchmarks and by satellite radar altimetry. The latter would be particularly valuable for detecting geoidal changes in elevations related to crustal movement.

High sea levels caused by storm surges are of the greatest concern in the coastal land reclamations of Hong Kong. Since the formation level of reclamations is a compromise between storm surge and rainstorm flood levels, the two are in conflict with each other. If the amount of ground settlement is large, the risk of storm surge is increased. On the other hand, if the formation level of reclamations is to be raised, the risk of rainstorm flooding is increased. Therefore, to reduce flood damage, high dykes, topping up, urban planning and flood pumping stations are the possible options.

Acknowledgements

I am particularly grateful to the Chief Engineer of the Port Works Division, Civil Engineering Services Department, Hong Kong Government and the Director, Royal Observatory, Hong Kong for the provision of data. All opinions expressed in this paper are purely my responsibility. I would also like to thank Dr. R. Wardlaw for Figures 3 and 4 and the Marine Department, Macau Government for Figure 6. This work forms part of a research project funded by the Croucher Foundation, Hong Kong.
References

BAKER, T., I. VASSIE and P. WOODWORTH, 1989: Taking the measure of the world’s sea levels. Commonwealth Science Council Earth Sciences Programme Newsletter, CSC(89)ESN1, 8-10.


LEE, C.M., 1981: Some geological factors and their influence on the seismicity of Hong Kong. Hong Kong Engineer, 9/12, 47-50.


STONER, T., 1989: The shrinking harbour. Saturday Review, 6th May, South China Morning Post, Hong Kong.


A Cold Spell in Hong Kong

Introduction

In winter the north-east monsoon can expose Hong Kong to flows of cold polar air. This occurred with a vengeance in December 1991 giving rise to an unusual spell of weather at the end of the month. As the Royal Observatory (1992) states, a temperature fall of over 20°C resulted in very cold weather and freezing and frosting on high ground. For example, Tai Mo Shan experienced temperatures below freezing and many sightseers converged upon the area to view the icing and frosting because of the unusual nature of the phenomena in Hong Kong. The last recorded incidence of frost on Tai Mo Shan was November 30th, 1987. Those interested in rare winter phenomena such as frost in Hong Kong are referred to Cheng (1970) while Bannister (1948) provides an account of a cold spell.

The Cold Spell

The temporal development of the cold snap is portrayed in Figures 1 and 2. They reveal that a large fall in minimum temperatures occurred on December 27th, 1991. However, absolute minimum temperatures were not recorded until December 28th at the Royal Observatory and the 29th in Tai Po and Macau. The Royal Observatory (1992) reports that absolute minimum temperatures occurred later in areas of the New Territories than at the Observatory. It also seems to have occurred later in Macau. It is difficult to account for this spatial variation. All three locations, that is to say Macau, Tai Po and the Royal Observatory, Kowloon experienced the lowest maximum daily temperature on December 28th, 1991.

Figure 3 illustrates the spatial variation of the cold snap. For stations which were well below 250 metres above principal datum minimum temperatures are recorded in the North and North-West of the Territory. As might be expected absolute minimum temperatures are associated with high ground such as Tai Mo Shan and Tate's Cairn. Figure 4, which plots minimum recorded temperature and altitude clearly reveals the control exerted by height and indicates that freezing level was around 380 metres. However, this almost certainly varied locally due to aspect, topography and other factors. Cheng (1970) presents data for February 5th, 1969, which also illustrates the control of altitude upon temperature. His data is plotted in Figure 4 for comparison with December 1991.

The daily weather charts of the Royal Observatory (1992) reveal that other parts of the South China Coast were affected by the cold snap. Results for Macau are given in Figure 2. The weather maps reveal that at 2 a.m. on December 28th a cold front extended from just southeast of Japan and the Ryukyu Islands to the southern tip of Taiwan, and down to the southern part of Hainan Island and to the coast of Vietnam. This meant that unusually cold temperatures were quite widespread. For example, at 2 a.m. local time December 28th Fuzhou had a temperature of 5°C, Shantou 6°C, Guanzhou 4°C, Zhanjiang 5°C, Haikou, 10°C and Hanoi, 9°C.

As described by the Royal Observatory (1992) the warm weather on Christmas Day (one of the warmest Christmases on record) resulted from gentle southeasterly winds. The dramatic fall in temperature which followed resulted from the southerly passage of a cold front ahead of a surge of the winter monsoon (Royal Observatory, 1992). The cold front had cleared the territory by December 28th, and the cold weather persisted...
Figure 1. Daily maximum and minimum temperatures recorded at the Royal Observatory and Tai Po for the period 25-31 December 1991

Figure 2. Daily maximum and minimum temperatures recorded at Macau for the period 25-31 December 1991
Figure 3. Spatial distribution of absolute minimum temperatures recorded during the period 25-31 December 1991

Figure 4. Absolute minimum temperatures recorded against altitude for the February 1969 (after Cheng, 1970) and December 1991 cold spells
on the 29th due to the northerly winds. Chin (1969) has authored a general discussion of cold surges over South China. He reports that, unlike the event of December 1991, the advance of cold air over South China can occur without any well organised frontal systems.

The cold snap did not only affect air temperatures in Hong Kong, the passage of the cold front being registered by the soil and running water in streams. Figure 5 shows soil temperatures recorded at 0800 hours at King's Park for various depths for the period December 25th, 1991 to January 1st, 1992, inclusive. It can be seen from the figure that the upper soil layer exhibits a significant drop in temperature on December 28th with the absolute minimum being found on the 29th. The fall in temperature was 9.8°C. Figure 5 reveals, that with increasing depth, the attainment of minimum temperature became increasingly delayed and the fall was also very much less. For example, at 50 cm the minimum, 18.7°C, giving a fall of 4.2°C, was on December 29th; while at 100 cm it was recorded on January 1st 1992, and the decrease in temperature was only 1.9°C. Figure 5 also reveals that at the 300 cm level in the soil the cold snap had little impact on temperatures.

Water temperatures in a small stream which drains a predominantly wooded drainage basin also reflect the cold snap. At the University of Hong Kong's Kadoorie Agricultural Research Centre in the New Territories air and water temperature are recorded between 0900 and 1000 hours each day. The data for December 25th, 1991 to January 1st, 1992 are shown in Figure 6. This reveals a marked drop in water temperature during the cold spell. However, this was not as large as the fall in air temperature and probably reflects the fact that water draining from the soil retained heat from the soil. The contrasting response of air and water at this station is also reflected in absolute minimum recorded temperatures which were 1.3°C for air and 12.5°C for water. Again the buffered effect of water due to heat from the soil is apparent. Figure 6 also reveals that the upturn in water temperature occurred one day later than that of air temperature.

**Conclusion**

Having discussed the causes and temporal development of the cold spell of December 1991 it is important to consider the effects that the large and rapid drop in air, water and surface soil temperatures might have on both man and the environment. An extreme illustration of this is the fact that four elderly people were reported to have died due to the cold (Royal Observatory, 1992) and street sleepers were forced to take refuge in Government shelters, (South China Morning Post, December 30th, 1991). Cheng (1970) discusses fatalities associated with cold weather in Hong Kong for the period 1948-1968.

Although damage to crops was not serious (Royal Observatory, 1992) the price of vegetables in the local market increased (South China Morning Post, December 30th, 1991). Vegetation development was affected and this was shown in many cases by a substantial loss of leaves and above 500 metres some native species were killed to ground level. (Corlett (1992), *in press*).

The cold spell undoubtedly had an economic impact on man, requiring increased heating of homes and offices, few of which are designed to retain heat effectively as such low temperatures are rare in Hong Kong. A local trader was cited as reporting that kerosene heaters were selling rapidly (South China Morning Post, December 30th, 1991). Finally, the effect of the very low temperatures accompanied by relatively high wind speeds on man's behaviour patterns and comfort should not be overlooked. According to Cheng (1970) cold spells can also cause poultry and pond fish to be killed causing problems to farmers. He lists the damage caused by cold snaps in Hong Kong for the period 1948-1968.

**Acknowledgements**

The authors would like to thank the Royal Observatory, Hong Kong for providing the soil temperature data and the information from Tai Po. The Macau Observatory must also be thanked for providing temperature data for Macau and Kadoorie Experimental Farm for the temperature data.
**Figure 5.** Soil temperatures recorded at King's Park Meteorological Station for the period 25 December 1991 - 1 January 1992.

**Figure 6.** Air and water temperatures recorded at Kadoorie Agricultural Research Centre for the period 25 December 1991 - 1 January 1992.
References

BANNISTER, R.C., 1948: A remarkable cold spell at Hong Kong. Weather 3(11), 344.

CHENG, T.T., 1970: Frost, Rime, Sleet and Other Winter Phenomena in Hong Kong. Technical Note 10 (Local), Royal Observatory, Hong Kong, 20 pp.


Editorial

A copy of the final text of the Framework Convention on Climate Change arrived on the electronic doorstep as we were finalizing this issue of TIEMPO. It prompted the initial response: Well, what have six intensive sessions of the Intergovernmental Negotiating Committee actually achieved? And then: What has been neglected because of the focus on anthropic climate change over the past four years?

It is well and good that the world’s politicians have, at last, shown some concern for our future but, keeping things in perspective, what about today? Would that a fraction of the IPCC/INC effort had been directed towards the endemic drought in Africa, the periodic flooding of Bangladesh or the myriad other weather- and climate-related problems that afflict the developing world. It is striking that a recurrent theme of the conference statements emerging from climate meetings in the Third World is the need to deal with present-day, as well as future, problems.

In this issue, we present a stimulating discussion by Narpat Jodha on the value of dual purpose response strategies which address existing environmental problems, whatever their geographical scale, at the same time as global change.

Anura Widanapathirana describes the historical and present-day development of irrigation and water harvesting, both important means of coping with environmental constraints. He highlights the need to realize their full potential both to meet present-day demands and to anticipate future change. His article demonstrates the wealth of knowledge to be gained from past and present experience in planning for an uncertain future.

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Water harvesting in Sri Lanka and Sudan

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We will return to the first question raised in this editorial in the next issue of TIEMPO.

The Case Against

Climate Aid

Patrick MCCully argues that climate aid may well do more harm than good given the history of large-scale development assistance. This feature is extracted from a more detailed discussion in the Ecologist (Vol. 21, No. 6, November/December 1991).

A huge increase in international aid is seen by many as an essential part of any effort to deal with global warming. However, this ignores the fact that aid has left a legacy of neocolonialism, debt, dependency, corruption and failure. The history of the transfer of western technologies to the Third World has been similarly dismal. Emphasis on the need for transfers of money and machinery to the Third World obscures the urgent need for radical changes in First World consumption patterns and global economic and political structures.

It is widely assumed that an essential element in any international agreement on climate change is a massive transfer of money and technology to the Third World. Without this, it is argued, it will be impossible for developing countries to curb their huge projected growth in greenhouse gas emissions. Indeed, the developing countries have made the transfer of adequate, new and additional resources from the First World a condition of their involvement in any international convention on global warming.

Non-governmental organizations have also stressed the importance of huge sums of money flowing to the South. The New Delhi-based Centre for Science and the Environment, for example, have suggested a system which would result in the high greenhouse gas emitting nations paying over US$100 billion annually to the rest of the world.

Energy analyst Michael Grubb of the UK Royal Institute for International Affairs, who also quotes a figure in the order of US$100 billion annually, states that: Resource transfer is a crucial element of any global abatement strategy. to pay for more efficient infrastructure and deployment of non-fossil sources; and to speed up the development process in order to give the best prospects for population control.

Huge sums could be raised by even a moderate level of taxes on the carbon emissions from industrialized countries. While not all of this money could be made available for the Third World, it would be politically and economically possible to create a large climate fund to help the Third World pay for limiting its greenhouse gas emissions. Much more difficult would be spending the money in a way which would actually limit carbon emissions while not exacerbating international and national inequalities.

Third World experience in the post-War era has been that the transfer of capital from the First World has led to dependency, debt and impoverishment. Far from helping the Third World, the economic instrument which goes under the ironic misnomer aid has been used to turn political colonialism into economic colonialism.

In the words of the Ethiopian economist Fantu Cheru: The overwhelming consensus among the poor in Africa today is that development, over the past 25 years, has been an instrument of social control. For these people, development has always meant the progressive modernization of their poverty. The absence of freedom, the sacrifice of culture, the loss of solidarity and self-reliance... explains why a growing number of poor Africans beg: please do not develop us!

Perhaps the most damaging misconception of aid is that it is donated as a magnanimous gesture by rich countries to assist the poor. Instead, aid is an instrument of foreign policy which is given to promote the donor's economic and security interests.

The control of any new climate funding has been the subject of much debate in the climate talks with most industrialized countries favouring channelling the funds through existing institutions, in particular the Global Environment Facility (GEF). The GEF has come in for strong criticism from environmentalists who have called on donors to halt further funding until the Facility is made more accountable and responsive to the desires of local communities.

Considering the harsh treatment that they have received from the World Bank and its sister institution the IMF, it is not surprising that the developing countries are fiercely opposed to the new funds they are calling for being channelled through any institution connected with the Bank. The G-77 group of 127 developing countries and
China favour the setting up of a new institution to deal with the climate funds which should be managed on the basis of equitable representation from developing and developed countries and should ensure easy access for developing countries.

Yet any new institution set up within the existing economic and political framework will be little different from the present international funding agencies. Its staff would be likely to be made up of bankers, economists and development experts transferred from existing agencies. These people would bring with them the same values, beliefs and theories which have caused the existing agencies to do so much harm to the people and environment of the Third World and would be doing business with the same government officials and business elites.

That the Southern countries are being impoverished by the current international financial system is not in doubt. Since 1982 the Third World has been paying an average of US$30 billion a year more to the North in debt repayments than they have received in new lending. But the answer is not to increase the financial flows within the framework which has caused the present problems, but rather to halt the flows for the Third World to repudiate the debt and to take on a minimum of new lending so that it does not get into the same situation again in another few decades. Any massive new flows of resources will merely deepen Third World dependency and repeat the mistakes of the last three decades of development.

Those in the industrialized countries who want to see both firm action on global warming and a better deal for the Third World would do best to concentrate on reducing the massive and wasteful use of energy in their own countries. First World energy consumption is the largest cause of global warming, the effects of which are going to strike the Third World first and hardest (if they have not already begun to do so). A radical change in this pattern of consumption would have a profound effect on the overall structure of Western society and also perhaps on the fundamental economic beliefs which have done so much harm to the world both North and South.

Demands for huge amounts of climate aid for the Third World give First World governments the excuse of not doing anything because they can claim it is too expensive and the First World will not stump up the money. But dealing with global warming is not a question of expense it is a question of economic and political restructuring.

Patrick McCully is an editor with NGONET, a Uruguay-based information clearing house, and an Associate Editor of the Ecologist.

Water Harvesting in Sri Lanka and Sudan

Anura S Widanapathirana discusses means of alleviating climate impacts on agriculture through water harvesting.

Agriculture is the main economic activity in all less developed countries (LDCs). In these countries it is heavily dependent on climate, of which rainfall is the most critical factor. Rainfall affects agriculture both in terms of its absolute amount and its distribution, including distribution over the entire agricultural landscape and over time within any given area.

Analysis of past rainfall performance in the LDCs shows that amounts have decreased slightly over the long-term but the distribution has changed remarkably. In many countries, the occurrence of the rains within the seasonal cycle has been delayed and the distribution within the rainy season has been disturbed substantially. With regard to the latter, the interval between consecutive rain showers has got longer while the intensity of any given shower has become torrential.

These variations are becoming the norm of the day now, more than ever before, thus affecting potential agricultural production in the LDCs. Since agriculture is the mainstay with regard to food supply, employment, income generation and the mode of livelihood, these changes will have serious repercussions for the people.

In order to alleviate the problems posed by climatic vagaries, the people in LDCs have evolved various strategies and practices over the history of their existence. These practices are still in place although several changes have been brought about due to institutional, political and other factors affecting their economies.
Sri Lanka is a tropical country with a rainfall of about 1000mm in the dry zone area which occupies about two-thirds of the total land mass. The dry zone has always produced the bulk of food for the people.

Water is brought by the seasonal rainfall. The bulk of the rainfall is experienced during the months of October-April (called the Maha season) while the lean period of May-September (the Yala season) brings very small amounts. During the Maha season, the rainfall can be very intense with 500-750mm over 24 hours and may cause more damage than benefit to the crop. Run-off is greater, soil erosion intense and the crop may be inundated with disastrous effects. The main problem in the Yala season is lack of water, not only for crops but for drinking also.

In response to climatic problems and for the efficient use of the rainfall, Sri Lankans have been experimenting with various techniques to collect rainwater, essentially run-off during the Maha season for use during the dry months. The main method of collecting is to construct large storage devices, tanks, by damming a natural depression. Through active experimentation, the Sri Lankans have devised various hydraulic structures to release the water stored in the tank for cultivation of the fields below by gravity irrigation. These ancient irrigation models for capturing, storage and utilization of run-off date back to the fifth century BC. Some of the tanks constructed during the pre-Christian era are in use even today.

As knowledge of irrigation expanded, the early settlers built small-scale reservoirs in every village they occupied for agricultural production and domestic needs. They learnt through continuous experimentation and testing to advance from village tank to major reservoirs during the period 65-109 AD. This is a remarkable achievement in the history of irrigation in Sri Lanka.

The climatic situation in Sudan is entirely different from that of Sri Lanka. Sudan is classified as an arid to desert country with low annual rainfall of 0-700mm. The main source of water for agricultural production is again rainfall. Agriculture is practised even with the lowest rainfall of 250mm brought in during two to three months (July to September). Even this meagre amount is not distributed over the entire agricultural land mass nor within the rainy months. Rainfed crop production is a highly risky operation.

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The system of water harvesting in Sudan involves diversion and collection of run-off, encouraging absorption into the soil mass, and farming which utilizes the moisture stored in the soil. The run-off itself drains out from a large area of the desert and is conveyed through seasonal streams called wadis. It is this run-off which is diverted to the land for temporary storage until it is absorbed fully into the soil mass. Experience shows that these seasonal rivers carry substantially large volumes of run-off even during poor rainy seasons.

Moreover, the continuous cultivation of the delicate sandy soils is found to be ecologically disastrous. This is believed to be a main contributing factor in the loss of environmental stability, thereby accelerating the process of desertification.

The second system is water harvesting. This system is practised in areas where alluvial soils are abundant, mainly along wadi areas. Such areas are distributed throughout the country. The productive capacity of alluvial soils is much higher compared to sandy soils. The operation is less risky since the source of water is run-off which is predominantly under-utilized. The wadis carry a considerable volume of run-off derived from a large catchment area during the rainy season. Even in years of poor rainfall,
With water harvesting, water is stored in the soil where farming is done and so the system is not dependent on local rainfall. Poor distribution of the rainfall, and not its insufficient amount, is the main factor explaining poor crop performance in many parts of the country. Water harvesting is, therefore, an important method of crop production in arid areas such as Sudan.

**Principles of water harvesting.** The process of water harvesting as practised in Sri Lanka and Sudan involves four main steps:

- the construction of structures to divert run-off;
- the construction of structures to facilitate its storage;
- operations to encourage water absorption into the soil;
- techniques to make use of stored water for crop production.

Both water harvesting and irrigation are similar up to the point of storage of run-off. In water harvesting, however, the structures are usually small while in the case of irrigation they are large. Water harvesting structures are earthen and there is a wide variation. The indigenous method is to construct small, U-, C- or V-shaped dykes, 25 to 35cm in height, on the alluvial soils. Such dykes can hold only a limited quantity of water drained from a small local catchment. In modern schemes, the harvester consists of rectangular-shaped dykes of about 1-2m in height. Water is diverted to water harvesters from streams which carry a large volume of run-off. The harvesters have gates and other mechanisms in order to control the volume of water stored and to discharge excess water.

Irrigation and water harvesting are entirely different with regard to the use of stored water. With irrigation, stored water is used under gravity flow via a network of irrigation canals and hydraulic structures. Water is released from the tank for irrigation of the fields below it. In water harvesting, crop production is practised on the grounds where run-off itself is collected. Hence, land is well prepared to absorb water before impounding. Water is allowed to remain within the dyke area for a period ranging from one to four weeks, depending on the type of dykes used. Planting is done on the wetted area behind the dykes after water has seeped into the soil. Crop plants make use of the soil moisture stored.

The type of crops, methods of planting, time of planting and other agronomic operations differ between the two systems. Crops planted under irrigation are paddy and other food crops such as chillies, pulses and vegetables. They are planted in October and the water is released from tanks for their growth until maturity. The Yala crops are usually planted in the month of April and are harvested in June and July. Seasonal showers provide part of the moisture needed for their growth. Paddy planting is done under submerged conditions while other crops are planted on raised beds.

The cropping patterns adopted with water harvesting are different from this type of scheme. In the case of indigenous schemes, it is only during the rainy season where, as in the case of modern schemes, two-season cropping, one in the rainy season and the other in winter, is undertaken. The rainy season cropping method involves tillling the land behind the earthen dykes using camel ploughs or, in the case of modern schemes, four-wheel drive tractors. Ploughing is done just before the onset of the rains. The rainfall is collected in the area covered by the dykes and a temporary reservoir is formed. Water is left on the surface until it seeps down, a process which takes a week to several weeks depending on the head of water collected behind the dykes. Once the water has completely seeped into the soil mass, planting is done on the surface.

By this time, the main rain showers are over and subsequent showers bring in only a limited volume of water. The crop uses the soil moisture stored subsurface, occasionally supplemented by the on-coming rains. Even without any rains, the stored water is quite sufficient to provide the water needed for the growth duration of the crop. The rainy season crops include millet, sorghum, cucumber, brinjils, capsicum, Sudan grass and jews-mallow. The crops are harvested during the October/November dry months.

The second cropping pattern is practised under modern schemes. It starts after removal of the first crop. This technique of crop planting involves making holes about 30cm deep in the soil and then planting at the bottom of these holes. At this depth, there is considerable moisture stored, sufficient for the crop until about March in the subsequent year. Frequent raking of the top soil is done in order to fill cracks formed in the soil, cracks which encourage loss of water.
Development of agriculture in this area should be based on the potential of the soils and their water holding capacity. Wadi soils are rich in nutrients and high in water holding capacity. These two factors offer an ideal atmosphere for agricultural production in an arid region such as western Sudan. In terms of water resources, it is estimated that the annual discharge of run-off in some wadis is as high as 560 million cubic metres. Only an insignificant fraction is under cultivation using small scale irrigation and water harvesting. The area utilized in some wadis ranges from a low of 30% to a high of 90% of the available area. The efficiency of operation of water harvesting is extremely low and there is great scope for increasing production both by expanding the area and increasing the intensification of already cultivated land.

Wadi soils are rich in nutrients and high in water holding capacity. These two factors offer an ideal atmosphere for agricultural production in an arid region such as western Sudan. In terms of water resources, it is estimated that the annual discharge of run-off in some wadis is as high as 560 million cubic metres. Only an insignificant fraction is used for agriculture and the rest disappears in the desert. In the meantime, drought and famine are common features. Development of agriculture in this area should make use of water harvesting.

The potential. About 30% of the cultivable area in Sri Lanka is under irrigation and this provides the bulk of paddy and other crops. The cropping intensity of paddy lands is about 140% due to the poor management of irrigation water resources. It has been shown that, if the efficiency of cultivation is improved, the entire requirement of paddy and all other food commodities could be produced under irrigation.

In Sudan, available evidence indicates that the total alluvial extent represents 34% of the total land area. The central and eastern plains have already been made use of for agriculture through water harvesting and gravity irrigation. In western Sudan, however, the area of alluvial soils extends over 1,899 square kilometres and only a small fraction is under cultivation using small scale irrigation and water harvesting. The area utilized in some wadis ranges from a low of 30 to a high of 90% of the available area. The efficiency of operation of water harvesting is extremely low and there is great scope for increasing production both by expanding the area and increasing the intensification of already cultivated land.

Both irrigation and water harvesting offer a wide variety of advantages for agriculture compared to rainfall-dependent forms of agriculture.

First, production is inevitably higher than in the case of traditional farming due to the high productivity of the soil itself, increased cropping intensity and better application of inputs including water.

Second, several crops required for the people, including paddy which is the staple diet of the Sri Lankans, can be produced with low risks. These crops cannot be planted under traditional farming systems with success. They also offer a high opportunity for exporting into other regions within the two countries, thus contributing to farm income.

Third, the two systems offer an opportunity of production during the lean agricultural season when no crops can be produced under traditional farming systems. This provides employment as well as continuous income beyond the traditional cropping season.

Constraints. There are several constraints and problems in making use of run-off for agricultural production through water harvesting or irrigation. The major constraints relate to technology and its diffusion, land tenure and agricultural support services while negative effects on the environment are a serious problem.

First, the effective technology of dyke construction which is the corner stone in water harvesting is not known to the majority of the people. Some well-to-do farmers make use of technologies which they themselves have developed and which are not known to the small farmer in particular. There is no mechanism for the generation of agricultural and irrigation technologies which are sustainable. Fertilizers, pesticides and heavy machinery have already caused untold damage to the environment and the scale of this damage increases steadily.

Second, there is no effective system for the diffusion of technological information among farmers and technologies generated at experimental stations are not always geared to meeting the needs of the farming community. Because of weak links between the experimental station and the farmers, the research tends to be academically-, rather than practically-, oriented. In Sri Lanka, the village-level agricultural extension system does not function effectively since the extension workers are no longer operating at this level. In Sudan, there is no village-level extension system. Under these
circumstances, the well-to-do farmer employs his own tactics to develop individual contacts while the poor farmer is helpless.

Third, land tenure is a complicated issue both in Sri Lanka and Sudan. There is no effective mechanism for the expedient settlement of land disputes and there is a high order of land fragmentation in Sri Lanka. The poor development of the non-farm sector has pushed people towards irrigation, already over-populated in Sri Lanka.

In Sudan, land owners are not interested in making use of the land when they have other avenues of income. In the meantime, a large number of people do not have access to alluvial land. In some pilot experiments, methods have been worked out whereby the land owner enters into an agreement with the farmer to till the land. The approach was found to be successful but has not received the blessing of the policymakers as yet.

Fourth, provision of supporting services such as credit, marketing, technical advice and other inputs to the farmer is a main constraint in both countries. In the case of irrigated agriculture, there is no systematic method to provide these services to the farmer who is otherwise dependent on the merchants.

In Sri Lanka, costs have gone up and farmer profitability has fallen drastically. The situation is worse in Sudan with the absence of agricultural credit and extension services. The main method used to construct dykes is the use of four-wheel drive tractors and/or heavy-duty earth-moving machinery, the service of which cannot be hired by the small farmer due to lack of purchasing power. There is also a scarcity of these machines in the region and lack of facilities for proper maintenance is a serious problem in remote areas where alluvial soils are found. Cost-effective means of construction which could be sustainable in remote areas should be made more widely known.

Finally, the environmental problems associated with irrigation and water harvesting are increasing at a high pace. In irrigation, the application of agro-chemicals, some of which have already been banned in other countries, has reached very high levels. Fertilizer application is also at a high level and the lack of organic matter in the soils has affected the retention of these plant nutrients. As a result, pollution of water bodies is a serious threat to the environment.

In Sudan, there is a trend towards the application of chemicals which were not needed in the traditional system. This increasing trend is because the farmers, the majority of whom are illiterate, are not knowledgeable in the proper handling of chemicals. The damage could be disastrous. The lack of vegetation accelerates the damage, increasing desertification. In the construction of dykes and other earthworks, as many existing trees as possible should be left intact as a buffer against the wind.

Conclusions. The climatic regime of the LDCs is undergoing a more rapid change than ever before. Shortened duration and poor distribution of rainfall and delayed onset of the monsoons are important changes, directly affecting agriculture in these countries. It is believed that these changes are going to become the norm of the future. Hence, development of agriculture along lines that are not directly dependent on climatic factors will pay higher dividends.

The development of agriculture in Sri Lanka and Sudan will have to be based on systems which do not depend on the vagaries of the climate. In this context, irrigation and water harvesting appear to be the main strategies for the future. These forms of agriculture have been in operation in the two countries since time immemorial and have been developed by the farmers themselves.

As recognized, however, there are several constraints facing the development of irrigation and water harvesting and solving these problems should receive the highest attention in future development strategies in order to save agricultural production in all LDCs which depend on irrigation and water harvesting. Protection of the environment in the process of agricultural production through irrigation and water harvesting is another serious issue which should receive full attention.

Anura S. Widanapathirana is an agricultural economist and has worked extensively in this position in both Sri Lanka and Sudan. He is at present working with IMPSA.

The Declaration of Fortaleza

The International Conference on Impacts of Climatic Variations and Sustainable Development in Semi-Arid Regions was held in Fortaleza, Brazil, during January 1992. The...
meeting was organized by the Funda o Grupo Esquel-Brasil as part of the Esquel Group’s environmental programme. The Esquel Group is a network of Latin American NGOs and individuals, concentrating on reconciling the long-term goal of sustainable development with the needs of low-income sectors in their region.

The International Conference on Impacts of Climatic Variations and Sustainable Development in Semi-Arid Regions (ICID) was a response to the call for regional meetings on environment and development in preparation for the Earth Summit in June 1992. It was sponsored by the Funda o Grupo Esquel-Brasil and the Government of the State of Ceará in conjunction with various Brazilian organizations.

The meeting considered the effects of climatic variability and change and the search for and implementation of sustainable development strategies to coherently confront the pressing issues of economic growth, environmental degradation and social equity in semi-arid regions around the world.

The conference started from the assumption that sustainable development, economic development with equity and environmental conservation, constitutes a necessary condition to enable the population to be more capable of facing climatic or other crises.

The specific objectives of the conference were:

- to update knowledge about the regional dimensions of climatic change in semi-arid regions, particularly the northeast of Brazil;
- to bring together case studies about the social, economic and environmental impacts of climatic changes in semi-arid regions;
- to discuss, in relation to the various case studies, the strategy of sustainable development as a way of enabling semi-arid regions to develop a permanent capacity to resist or adapt to the actual and future effects of climatic variability and change;
- to produce a series of conclusions, statements and recommendations in the areas of research and public policy;
- to contribute to the preparatory process of UNCED, making available to its organizers the documents, results and recommendations of the ICID; and
- to catalyze a systematic dialogue between researchers, policymakers and institutions concerned with the problems of semi-arid regions and sustainable development.

ICID brought together 800 participants drawn from members of the national and international community of scientists, technicians, representatives of public and private sector organizations, decisionmakers and politicians from 45 different countries in the world. The event proved an important opportunity for the exchange of experiences and information among many countries and regions. In addition, ICID has established the foundations for further collaborative efforts in action-oriented research, policymaking and programme design.

The products of the event included a political document the Declaration of Fortaleza and a summary of the discussions and recommendations of the ten working groups convened in the conference. Both documents will be delivered to the UNCED Secretariat as an attempt to include relevant issues concerning semi-arid regions in the UNCED agenda.

THE DECLARATION

Whereas

Many semi-arid regions are economically marginal, therefore highly vulnerable to any changes in the global climate, and often lack the financial and technical resources required to initiate major adaptations to environmental changes. There is a growing recognition of the need for international action on the issues of global change, environmental degradation and equity. There is great need for urgency arising out of current conditions in the semi-arid regions of developing areas.

1. We, women and men of the civil society, have met in Fortaleza, State of Ceará, Brazil, from January 27 to February 11, 1992, convened by the Government of the State of Ceará and Funda o o Grupo Esquel-Brasil, with support of several other national and international organizations. We are a multidisciplinary group of scientists, academics, government officers, social workers, environmentalists, politicians, religious leaders and other persons concerned with the interactions between human beings and their natural and social environment, and have many decades of study, research and practical experience in the development of semi-arid regions worldwide.

2. We address all women and men concerned with equitable development and a decent life for everyone in harmony with nature, and also to the
women and men empowered by society to take the crucial decisions related to the welfare of present and future generations.

3. We issue this Declaration at a particularly important moment, since in June 1992 the United Nations Conference on the Environment and Development (UNCED) will meet in Rio de Janeiro, Brazil. The determination, energies and resources of all countries of the world will be mobilized in a great effort to stop the processes of environmental deterioration that threaten our future. It would be a great loss to humanity if, on this occasion, the plight of semi-arid regions and their environmental degradation is not recognized and discussed by the nations attending UNCED.

4. Although semi-arid zones in all regions of the world are at risk, our primary concern is the present and future conditions of people and their environment in the semi-arid regions of developing countries. These regions are characterized by their extreme vulnerability to highly variable rainfall regimes and inadequate human activities, and they are places where great human suffering occurs: abject poverty, recurring famines and outmigration, uncertainty of agricultural production from one year to the next, and consequently uncertainty about the continuity of human settlements and their rich cultures and civilizations. Though semi-arid regions have common problems, they have not sought sufficiently to strengthen each other by sharing experiences and knowledge.

5. The deterioration of the environmental and human conditions in these regions, which in many cases include significant desertification processes, have widespread socio-economic consequences which affect directly and indirectly all the regions of the world. In addition, as semi-arid ecosystems are fragile they are highly susceptible to effects of global warming and other environmental changes brought about by unsound industrial and agricultural activities and unwise, unsustainable development practices.

6. The specific recommendations widely discussed and supported by the participants in ICID may be summarized in the following basic principles, which should guide efforts to develop semi-arid regions:

i. The origin of poverty and environmental degradation in these areas is basically socio-economic and political. Any serious effort to develop those regions should be based on socio-economic strategies that include the participation of civil society and political commitment, structural reforms, land-tenure reform, access to water adequately managed and improved agricultural policies at national and regional levels. The overall improvement of education and skills is a precondition for the achievement of the development goals of these strategies.

ii. The environmentally sustainable economic and social development of semi-arid regions must be pursued as the ultimate goal. Sustainable development must be understood as including equitable distribution of wealth and access to resources, respect for local diversity, an adaptation of the scale of human activities to those which are compatible with the ecological regime taking into account the needs of present and future generations and maintenance and increase of long term productivity.

iii. Past and present mistakes and ill-conceived policies have produced a situation in those regions where most of them have reached the limits of their productive capacity, a situation which can not be reverted without large national and international financial efforts. A fair approach to this problem indicates that some costs will have to be borne by the national economies but that others are clearly the responsibility of the international community. Efforts to define the scope of each one’s financial responsibility must be associated to the increase of the capacity of developing countries to finance their own sustainable development, including the appropriate resolution of the external debt burden of indebted developing countries. Trade discrimination particularly hurts the semi-arid regions, and should be removed. It is also essential that semi-arid regions be assured access to new technologies, and international rules to promote the transfer of technologies should be implemented as soon as possible. In addition, it is emphasized that measures aiming at the restoration of degraded areas and prevention of further environmental deterioration are urgently needed.

iv. Efforts to redress the present impoverished situation must be based on rigorous research and study but can not neglect the knowledge of the traditional populations, who for centuries sustained life in those regions. These efforts will not reach their objectives if civil society and grass root movements are not involved in the national and regional decision making process.

v. Biodiversity has an actual and potential economic importance. The development of these regions should take into account the sustainable use and conservation of this resource. Adequate national legislation and international conventions should prevent abusive exploitation. The
countries, cultures and regions from which each particular genetic resource or its natural or synthetic derivates originate must be fairly compensated by those who acquire or transform them for economic gain.

vi. Semi-arid regions must learn from each other. Networks should be created and existing ones strengthened. They would serve two needs: at the research level they would be used to exchange information, discuss methodologies, report research findings and develop joint activities; at the level of planning for sustainable development, they will provide a forum for dialogue and exchange of experience among experts, decision makers and organized segments of civil society.

vii. History shows, and modern science confirms, that semi-arid regions have the natural resources required for the development of human settlements where it is possible to establish adequate production systems, equitable forms of social organization and rich and prosperous cultures. We are not facing hopeless situations but a set of environmental and socio-economic circumstances which require special attention and priority treatment to allow for the full development of the potentialities of semi-arid regions and their peoples.

Further information: The organizers of the International Conference on Impacts of Climatic Variations and Sustainable Development can be contacted at ICID, Funda o Grupo Esquel-Brasil, Edif. ASCBSAS Conj. 06, Bloco L-s/801-A, 70070 Brasilia DF, Brazil.

Conferences

Focus of the conference will be strategies for dealing with issues arising from socio-economic development processes with the environment as a particular bias. Representation to be at the level of heads of state or government plus a broad participation by NGOs, particularly from developing countries.

Details: UNCED, Route de Florissant 160, PO Box 80, CH-1231 Conches, Switzerland.

1992 Quadrennial Ozone Symposium, Charlottesville, USA: 04-06-92 to 13-06-92
The University of Virginia is hosting this international symposium. Sponsors include WMO, US EPA and the National Science Foundation. The conference includes oral and poster presentations as well as a number of social activities such as hiking and canoeing.

Details: Quadrennial Ozone Symposium, PO Box 988, Greenbelt, Maryland 20768, USA.

Global Climate Change: Impacts on Terrestrial Ecosystems, Bad Durkheim, Germany: 14-06-92 to 18-06-92
The conference aims to provide an opportunity for exchange of scientific information between atmospheric and biological scientists regarding global climate change and effects on terrestrial ecosystems. Primary objectives are to assess the current state of knowledge of atmospheric processes, to discuss effects of global climate change and to determine future research needs.

Details: Kay Russell, Elsevier Science Publishers, Conference Dept, Mayfield House, 256 Banbury Road, Oxford OX2 7DH, UK.

Geophysics and Environment: Background Air Pollution, Rome, Italy: 16-06-92 to 18-06-92
Conference topics to include monitoring, relationship to climate, national and international observation networks, data exchange and coordination.

Details: Sabino Palmieri, Universita Degli Studi Di Roma, La Sapienza, Dipartimento di Fisica, Pile Aldo Moro, 2-1-00185 Rome, Italy.

Ocean Management in Global Change, Genoa, Italy: 22-06-92 to 26-06-92
Conference intends to examine present and future trends in the use of ocean resources and preservation of the marine environment. Aims to identify ocean management issues from national, regional and global perspectives and examine trends in theory and practice of ocean management.

Details: Adalberto Vallega, University of Genoa, Pallazo Serra Gerace, Via Sottoripa 5, 16123 Genoa, Italy.

Living with Industry: The Next Ten Years, Huddersfield, UK: 07-07-92 to 10-07-92
An international conference intending to examine issues such as: past and present relationships between urban environment and quality of life;
role of local government in monitoring, managing and improving local environments; and, responsibility of industry towards the environment.

Details: A S Trescott, Living with Industry, Dept of Geographical and Environmental Sciences, The Polytechnic, Queensgate, Huddersfield HD1 3DH, UK.

Pre-Congress Meeting of the Commission on Climatology, Pennsylvania, USA: 03-08-92 to 08-08-92

Conference has three main themes: climatic change; tropical climate; and, local climate. Discussion and workshops on climatological topics to assess present status and research directions needed.

Details: John Arnfield, Dept of Geography, Ohio State University, 103 Bricker Hall, 190 North Oval Mall, Columbus, Ohio 43210-1361, USA.

Industrial and Third World Environmental Assessment: The Urgent Transition to Sustainability, Washington DC, USA: 19-08-92 to 22-08-92

This year's conference, hosted by the World Bank, aims to compare methods of environmental assessment in both Third World and industrial countries in relation to sustainable development. IAIA hopes to advance impact assessment and foster its application to impact situations, from global to local.

Details: Maurice E Voland, IAIA Executive Director, PO Box 70, Belhaven, NC 27810, USA.

Second International Conference on Modelling of Global Climate Change and Variability, Hamburg, Germany: 07-09-92 to 11-09-92

Conference is a follow-up to one held three years previously. Aims to provide an opportunity to present new research results in this field and to discuss recent developments and the outlook for the future.

Details: Dr Lydia Dumenil, Local Organizing Committee, Max-Planck-Institut fur Meteorologie, Bundesstrabe 55, D-2000 Hamburg 13, Germany.

Population and Environment, Oxford University, UK: 09-09-92 to 11-09-92

Conference intends to explore the environmental consequences of population growth, and the effects of environmental change on population growth and distribution. Topics include: population movement and land use change; rural household economies; climate change and ecological limits; and, influencing development policies.

Details: Basia Zaba, Centre for Population Studies, 99 Gower St, London WC1E 6AZ, UK.


Conference aims to cover present and future energy issues. Topics include consequences of production, relation to life and the need to develop energy as a sustainable service to humankind.

Details: WEC - 15th Congress, Avda. de America, 32 - 9a, 28028 Madrid, Spain.

Mountain Environments and Changing Climates, Davos, Switzerland: 11-10-92 to 16-10-92

Co-sponsored by WMO, the Swiss Meteorological Institute and the American Meteorological Society amongst others. Will include invited speakers, oral presentations and panel sessions intended to stimulate discussions. Conference will bring together climatologists, biologists, hydrologists and ecologists to discuss various aspects of mountain environments in changing climates.

Details: Dr Martin Beniston, ProClim, National Institute for Climate and Global Change, PO Box 7613, CH-3001 Bern, Switzerland.

World Congress for Education and Communication on Environment and Development, Toronto, Canada: 17-10-92 to 21-10-92

ECO-ED’s purpose is to stimulate informed action by improving the accuracy and quality of education and communication relating to the environment and sustainable development. Intended participants include educators, communicators, NGOs, politicians, scientists, business representatives and other concerned citizens.

Details: ECO-ED, Congress Canada, 191 Niagara St, Toronto M5V 1C9, Canada.
Conference to include oral and poster presentations, lectures and panel discussions with greater emphasis on Southern Hemisphere oceanography than earlier conferences in this series. Papers are invited and must be submitted no later than 1 August 1992.

Details: Dr David Karoly, 4ICSHMO, Centre for Dynamical Meteorology, Monash University, Clayton, Victoria 3168, Australia.

Environmental Consciousness and the Mass Media,
Dresden, Germany: 01-04-93 to 05-04-93

An international congress planned for scholars, scientists, media professionals and environmental activists to examine means through which environmental issues shape the public consciousness. Main themes to include mass media, North-South and East-West environmental dialogue, and identifying environmental problems in the public consciousness.

Details: Patrick Wilkinson, Deutsches Hygiene-Museum, Lingnerplatz 1, D0 8010 Dresden, Germany.

Climate Change, Natural Disasters and Agricultural Strategies,
Beijing, P R China: 26-05-93 to 29-05-93

An international symposium intended to review studies of climate impacts on agriculture, forests, sea level rise, land use and other human environmental factors. Aims include the exchange of ideas, views and techniques for forecasting and mitigating these disasters and promoting international cooperation in environmental protection.

Details: Prof Lu Guangming, Beijing Agricultural University, 100094 Beijing, P R China.

The Need For Dual Purpose Strategies

Forum is presented by NARPAT S JODHA who argues that more attention should be paid to strategies which alleviate current environmental and socio-economic stress and which, in the longer-term, will reduce global change. This article is abstracted from "Understanding and Responding to Global Change in Fragile Resource Zones" in The Regions and Global Warming: Impacts and Response Strategies, Oxford University Press, New York, 1992.

While concern about global warming has generated awareness and fear, it must be said that the climate debate has produced more noise than concrete collective action on the problem.

The generation of panic rather than the promotion of concrete remedial measures and the frequent recycling of similar information and recommendations at global warming symposia tend to suggest a state of stagnation or crisis in the field.

One basic reason for the inaction that affects both abatement and adaptation strategies is the existence of complex and persistent uncertainties in the climate change forecasts, especially in the precise extent of predicted impacts.

These uncertainties combine with the risk-averse and calculating nature of decisionmakers. The net result is the suggestion that scientific evidence of the problem is not firm or definite enough to induce collective action.

This difficulty is compounded by the fact that action has to be taken by a community of nations with all its diversity in terms of perceptions about potential gains and losses due to global environmental change and the measures to be taken against it.

The uncertainties tend to promote a wait and see attitude towards the problem. This may prove risky for a number of reasons.

First, there is the cumulative nature of the warming, the risk of surprises or sudden shocks and the possibility that certain changes may be irreversible by the time firm knowledge on the warming problem is generated.

Second, waiting tends to dilute the concern, commitment and enthusiasm for the problem and, hence, slackens the preparedness to act at the appropriate time.

Finally, negotiations on global warming may take a very long time due to the complexities and the involvement of nations with diverse perceptions, adding further to the waiting period even after scientific understanding has improved.
There is clearly a need for action despite the uncertainties in the climate change forecasts.

The process of action despite uncertainty can start with the identification of what is reliably known, the certainty components which exist alongside the complex of uncertainties associated with the pace and pattern of global environmental change and its impacts.

Response strategies can build upon these certainty components of the problem. Selected with care, they can also have a slow and significant impact on components of the problem which are uncertain. In this sense, they will prove to be dual purpose strategies.

Despite their importance, inadequate attention has been paid to certainty components. This is a result of skewed perspectives on global environmental change.

Global change has several dimensions arising from, for example, the multiplicity of causative factors and involved processes and the diversity of potential response approaches. However, only some dimensions of the global environment change phenomenon, particularly those relating to the geosphere and biosphere systems of the earth, have been the major focus of scientific work, debate in the media and policy study.

Unfortunately, these dimensions, which involve complex biogeochemical variables and their interactions, have great degrees of uncertainty associated with them.

Certain historical and institutional factors have contributed to this state of affairs, most notably the involvement of specific scientific disciplines in initial work on the subject and their continued dominance, as well as the newness of the problem and the noise potential of particular aspects.

There has been a tendency to focus on systemic change (whereby change occurring in one place affects elsewhere in the system) and geocentric perspectives (focusing on the whole earth). Meanwhile, important dimensions such as cumulative change (whereby change in one place does not affect change elsewhere of itself but, when amassed, these widely-replicated activities acquire the potential to influence the whole system) and anthropocentric perspectives (emphasizing nature-society interactions) are passed over.

Deforestation, desertification and other regional processes occurring in different, spatially-separated locations ultimately influence the global situation and are prime examples of cumulative change. Directly or indirectly, they influence the processes of systemic change such as global warming and warrant greater attention.

Dimensions of global change covered by the cumulative category, such as deforestation and extractive land-use practices, are more visible and involve little uncertainty. It is, therefore, easier to sell remedial measures to decisionmakers. They relate to current difficulties rather than the more uncertain future problems predicted by the global change forecasts.

Because of the link with larger-scale change, control of the processes giving rise to cumulative change may help to combat the emergence or impact of systemic change.

By managing current problems of deforestation and desertification, one can guard against the rapid decline in the natural carbon dioxide sinks. By managing current problems in crisis-affected areas due to resource degradation and poverty, one can enhance the people's capabilities to withstand the impacts of future global environmental change.

There are several areas of convergence between manifestations of systemic change, such as regional climate change impacts, and current environment or development problems, especially in the developing world. In this respect, one may refer to the current problems in dry tropical regions, such as ground water depletion, soil erosion, crop yield decline, deteriorating status of forest and pastures, recurrent droughts and even the overall poverty of the people.

In the context of global warming, these very problems would emerge as part of what are described as first-, second- and third-order impacts. They are manifested, respectively, through deterioration in the productive environment and resource base of agriculture, reduced suitability of well-adapted farming practices and deterioration of macro-economic situations due to the decline of agricultural prospects.

Deforestation, for example, by influencing the hydrology of the region, influences the resource base and production environment of agriculture. By weakening the forest-farming linkages, forest destruction affects the farming system. By constraining biomass supplies, it affects the macro-level policies on fuel and energy options.

Greater attention to the anthropocentric perspective, which focuses on human survival and
welfare considerations while dealing with different phenomena including global change, may prove instrumental in generating concern for evolving strategies to manage cumulative change.

It is proposed, then, that a practical approach to the identification of adaptation strategies be based on the convergence between the impacts of current crises that contribute to cumulative change and those expected from systemic change and between remedial measures which deal with both.

Dual purpose strategies that are primarily focussed on current problems but have the potential to resolve future problems offer an important area for further exploration and action. Such strategies would have many advantages.

First, they would not be obstructed by the complexity of uncertainties.

Second, the options are easy to conceive and more acceptable to decisionmakers, particularly in the developing world where efforts are concentrated on current problems rather than on climatic change in the distant future.

Third, the problems caused by inter-country differences and perceptions on costs and benefits would be reduced.

Finally, there would be no risks of redundancy of options and associated resources if the predicted change scenarios do not materialize as immediate benefits would accrue regardless.

This approach cannot substitute for measures required to deal directly with the global warming problem. It is helpful only to the extent to which cumulative change plays a role in climate change and the accentuation of its impacts.

Its strongest point is that it helps in integrating the concerns of current problems with those of the future impacts of global change, advocating strategies which integrate the two concerns whilst minimizing obstructions arising from uncertainties in, for example, the climate forecasts.

Dr Narpat S Jodha is Head of the Farming Systems Division at the International Centre for Integrated Mountain Development in Nepal.

The aim of the Information Unit on Climate Change (IUCC) is to support the work of decisionmakers by providing reliable, topical and accessible briefing materials on global warming. The needs of developing nations are the primary, though not the exclusive, focus of the Unit’s work.

The IUCC is based in Geneva. It was set up in 1991 by the United Nations Environment Programme (UNEP) in response to the Second World Climate Conference conclusion that a well informed public is essential for addressing and coping with as complex an issue as climate change.

Drawing on the resources of UNEP’s Global Environment Monitoring System, the Intergovernmental Panel on Climate Change and other expert groups, IUCC provides a range of services and briefings which can be tailored to the specific requirements of the client organization or nation.

Presentations. Based on the theme selected by conference organizers, IUCC will identify the most appropriate speakers, arrange for their participation and develop suitable presentations. Videos and documents for distribution can be provided and post-meeting services are available to meet further information needs.

Fact sheets. Prepared by experts in relevant fields, fact sheets can be provided which summarize the complex issues of climate change in a concise and accessible fashion. Over 100 fact sheets are available. These cover topics ranging from the causes of climate change through the potential impacts of global warming to policy responses. They are updated regularly. Fact sheets that are country- or topic-specific can be provided as needed.

Film information services. IUCC is cataloguing documentaries on climate change and including information on where broadcast rights can be obtained from and at what charge. Many documentaries can be broadcast free in developing countries. IUCC is also producing its own series of climate change videos for use in its own presentations. These videos may be available for public broadcast.

Electronic information services. Much of the information produced by IUCC is available through computer networks and information systems such as Omnet, GreenNet, BITNET, Environet and CompuServe. In addition, IUCC has its own on-line information system which can be interrogated directly.
Other information services. In response to particular needs, IUCC can produce articles and reports on all aspects of climate change, including analyses of country-specific impacts or policy options. Press releases and media kits can also be provided.

Further information: Governments, commercial companies and other non-governmental organizations wishing to make use of the services of the IUCC should contact IUCC, UNEP, Palais des Nations, CH-1211 Geneva 10, Switzerland.

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IPCC Updates the Consensus

An update of the authoritative 1990 report on the basic science of global warming has been released by the Science Working Group of the Intergovernmental Panel on Climate Change (IPCC). A summary is available free of charge from the IPCC Secretariat and the full text is being published by Cambridge University Press.

The report concludes that the findings of recent research do not affect our fundamental understanding of the science of the greenhouse effect and either confirm or do not justify alteration of the major conclusions of the first IPCC Scientific Assessment.

The report does expand on two components of the problem referred to, but not elaborated on, in the earlier assessment.

First, a more accurate assessment has been made of the relative contribution of the chlorofluorocarbons (CFCs) and the reduction in ozone amounts in the lower stratosphere resulting from CFC increases. It turns out that a fair proportion of the warming caused by increased CFC concentrations may have been offset by cooling associated with ozone depletion. The implication of this finding is that it shifts the control focus back onto carbon dioxide, undermining the comprehensive approach.

Second, there is more confidence in the cooling effect of the aerosols resulting from sulphur emissions produced by fossil-fuel combustion. The IPCC report concludes that this mechanism may have offset a significant part of the greenhouse warming in the Northern Hemisphere during the past several decades.

These new findings represent both good news and bad news. On the one hand, estimates of the future global warming will have to be revised downwards somewhat, reducing the scale of the global impact of climate change. On the other hand, lower latitudes may experience a more severe change in climate than previously anticipated.

The sulphate effect is largely confined to the Northern Hemisphere and so there will be a different rate of warming in the two hemispheres. This could mean increased instability in the equatorial climate system, with profound implications for the monsoon and other regional climate processes.

The sulphate effect may also complicate the process of controlling emissions. As fossil-fuel use is reduced, short-term warming due to the drop in sulphur emissions may temporarily mask gains due to decreased releases of carbon.

Finally, the update reports that methane emissions from rice paddies may have been previously over-estimated.

It would appear that further research is demonstrating more and more just how complicated a problem global warming is, underlining the need for precautionary action in the face of such an unpredictable and far-reaching threat.

Further information: IPCC Secretariat, Case Postale 2300, 1211 Geneva 2, Switzerland.

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A Weather Eye On.....

Weather Eye takes a sobering look at the Fifth Session of the Intergovernmental Negotiating Committee (INC) held in New York in February 1992. With many thanks to Eco.

IN THE FOREST OF BRACKETS...

Considerable time was, once again, spent dealing with the multitude of brackets which afflicted the draft text. The performance of the INC delegates was carefully monitored by an alert observer, stopwatch in hand. Working Group II managed to approve one line of text every 30 minutes during one session. Even this pace was not maintained. On another day, not a single bracket was removed nor a single word of text debated. Almost as many brackets left as minutes to
negotiate them, commented co-chair Robert van Lierop.

ROUND AND ROUND...

The structure of the INC process is leading to problems. Working Group I is not keen to specify commitments on emission reductions without mechanisms in place to make them workable. Meanwhile, Working Group II is arguing that progress cannot be made on mechanisms until the commitments are identified.

PRINCIPLES AT STAKE...

Working Group I devoted much of one morning to discussing the principle of including principles. A number of industrialized nations felt that the section on principles in the draft text was unnecessary as it duplicated material elsewhere. On the other hand, many developing nations considered its inclusion essential.

Ghana, for example, commented that the principles are dear to the developing countries and China stressed the need for principles as a compass to guide the remaining articles. It was proposed that the issue be resolved by an informal meeting. Just how casual can you get?

SPECIAL CONSIDERATION...

Few would argue against special consideration being given to the nations most at risk from climate change and sea level rise. But it is now being proposed that certain industrial nations should also be granted special consideration under the provisions of the climate treaty because they are heavily dependent on fossil fuels.

Professor Bert Bolin, releasing the latest Intergovernmental Panel on Climate Change findings in New York, warned that even a very modest achievement to reduce the rate of increase of carbon dioxide in the atmosphere as aimed for by some OECD countries might be compromised by special allowance amongst the OECD countries.

A MARRIAGE OF CONVENIENCE...

In an attempt to resolve disagreement on which draft text should act as a basis for discussion, the Working Group II co-chair proposed that two alternative versions be married. The delegate from Antigua and Barbuda responded that, given the time available, this would be a difficult task requiring a short courtship, followed by a quick marriage and consummation, high fertility rate and short gestation period.

AID BUT NOT ACTION...

While continuing to equivocate on the issue of domestic emission control, the United States is prepared to commit money so that other nations can assess the need to take action.

A contribution of US$25 million over two years will be made to enable developing nations to assess their greenhouse gas emissions and means of reducing them. A further US$50 million will go to the core fund of the Global Environment Facility.

Michael Oppenheimer of the Environmental Defense Fund described the proposal as mere window-dressing and an attempt to buy off the developing world.

THE END IN SIGHT?...

The final session of the INC was held in New York from April 30th to May 8th. Though few believe that this will be the end of the climate treaty saga.
initiatives and needs at the regional level, especially within a region with its own strong traditional cultural identity such as the Pacific. The conference found this global to regional scaling problem ran through all areas of discussion.

The conference drafted a work programme on climate change science, potential impacts and responses and on ways of explaining greenhouse issues in the region. This will be put to international aid and research agencies for funding. Wherever possible, the programme will be carried out by the islanders themselves.

The draft work programme for the SPREP Climate Change Programme will be tabled for approval at the September SPREP IGM to be held in Western Samoa. The programme is made up of three sections:

- climate change science;
- impacts and responses; and
- climate change information and awareness raising.

Under the first section, participants focused on the need for the SPREP member countries to have the efforts of climate change scientists directed towards both short- and long-term predictions of change. Delegates highlighted the importance of the impacts of extreme climatic events such as cyclones and droughts in the region and concluded that any changes in climate should be viewed in this context.

The division between the assessment of the potential impacts of climate change and the formulation of strategies to mitigate such impacts was seen as good in theory, but unrealistic in practice. Under the second section of the research programme, a range of combined impact and response assessments was suggested, focusing on coastal ecosystems, water and marine resources, agriculture and food, security and land use, commerce, transport and communication, waste management, health, biodiversity, forestry and population relocation.

In the final section, participants concentrated on the exchange and sharing of information between island governments, their people and the international scientific community.

The world’s politicians will be talking about limitation of the greenhouse effect for many years to come. Meanwhile, the Pacific Islanders will be singing about the potential catastrophe they face. It may be better for the world if the islanders of the South Pacific did the talking while the politicians of the developed world did the singing.

SADCC Considers Climate Change

Windhoek, Namibia, was the venue for the First SADCC Conference on Climate Change during March 1992. Over five days, participants were presented with a wide range of papers on climate change. Both global and regional perspectives were covered with particular emphasis on the present-day situation with drought affecting much of southern Africa.

The aims of the conference were:

- to create awareness among SADCC decision makers about climate change and its possible effects on southern Africa;
- to develop a framework for policy formulation on climate change and its effects on sustainable development; and
- to establish a regional group of experts and identify needs for the development of policies, action programmes and research.

The meeting was organized by the Environment and Land Management Sector of the Southern African Development Coordination Conference (SADCC) in cooperation with SADCC Sectors on Energy, Food Security and SATCC, the International Institute for Environment and Development, the University of East Anglia, the University of Virginia, the United Nations Environment Programme and the World Meteorological Organization.

The conference statement noted the significance of global warming for the SADCC nations, already hard-pressed by climate variability, and discussed potential impacts on water resources, agriculture, energy, natural resource, health and the economy. Working groups advanced
recommendations for action and called for further work on adaptive responses.

Further information: Jan Larsson, SADCC ELMS, PO Box 24, Maseru 100, Lesotho.

Contact Addresses

Patrick McCully, NGONET, Casilla Correo 1539, Montevideo, Uruguay.


Narpat S Jodha, International Centre for Integrated Mountain Development, GPO Box 3226, Kathmandu, Nepal.

South Pacific Regional Environment Programme, PO Box 240, Apia, Western Samoa.
News and Announcements

This section is intended for dissemination of news and announcements by the Society or any of its members. If members wish to relay any news or make any announcement of interest to members which is related to the aims of the Society they should mail or fax such information to the Editor-in-chief along with their name(s) and membership number(s).

CALL FOR PAPERS

Third International Conference on School and Popular Meteorological and Oceanographic Education, July 14-18, 1993, Toronto, Canada

The Third International Conference on School and Popular Meteorological and Oceanographic Education will be held in Toronto (Canada) from July 14th to 18th, 1993. Like its predecessors, this conference will focus upon the roles of meteorology and physical oceanography in science education and the benefits to be gained from improving environmental awareness and literacy, particularly weather awareness, meteorological literacy and knowledge of the sea. It will also focus upon uses of modern technology in meteorological and oceanographic education, as well as ways and means of improving disaster preparedness in the less-developed countries of the world. The conference will be hosted by the Canadian Meteorological and Oceanographic Society and will also be sponsored by the Royal Meteorological Society and the American Meteorological Society.

Temperature safaris; a national balloon launch; dry ocean travel logs; cumulus clouds made out of shaving cream; soda pop bottles used to make vortices; the radiation balance of a bed of nettles' rainbows in the classroom; soap bubbles in the boundary layer: it's amazing what teachers do to excite interest in the atmosphere and the oceans! There were ideas aplenty at the international conferences on school and popular meteorological and oceanographic education which were held in 1984 and 1989. If you missed these events, you should consult Weather Education (Walker, 1985) and the preprint volume prepared for the second conference (American Meteorological Society, 1989).

The conference is intended for all who are interested in school and popular meteorological and oceanographic education, be they teachers, educationists, publishers, amateur observers, professional scientists, equipment manufacturers, journalists, weather hobbyists, or whatever.

The format of the conference will be mixed, with poster displays, oral presentations of papers and hands-on demonstrations of equipment and teaching aids. In addition, there will be an exhibition of books, videotapes, computer software and other resources for teachers.

Abstracts of papers and descriptions of demonstrations must be received by 30 November 1992. The official language of the conference is English. The abstracts and descriptions should not exceed 500 words and authors should indicate the preferred format for presentation (oral or poster). Those who wish to demonstrate equipment must provide details of special requirements. Authors will be notified of acceptance by 15 January 1993. A preprint volume will be prepared, for distribution at the conference. Special paper and typing instructions will be issued to the authors of accepted presentations, together with details of submission deadlines.

All correspondence should be addressed to:
Steven B. Newman, Dept. of Physics and Earth
Sciences, Central Connecticut State University, New Britain, CT 06050, USA (phone: 1-203-827-7248; fax: 1-203-827-7982; e-mail: NEWMAN @ CTSTATEU.BITNET). Alternatively, information can be obtained from Malcolm Walker, Dept. of Maritime Studies, University of Wales College of Cardiff, Aberconway Building, PO Box 907, Cardiff, CFI 3YP, Wales, UK (phone: 44-222-874271; fax: 44-222-874301; e-mail: WALKERJ @ UK.AC.CARDIFF).

References:


FORTHCOMING CONFERENCE

Second Western Pacific Geophysics Meeting, August 17-21, 1992, Hong Kong

The Second Western Pacific Geophysics Meeting, sponsored by the American Geophysical Union, will be held August 17-21, 1992 in Hong Kong. The first Meeting was held in Kanazawa, Japan and was a great success.

The meeting is intended particularly to serve the needs of geophysicists interested in problems being studied in the Western Pacific region, but papers on all related aspects of geophysics are encouraged.

Second International Conference on East Asia and Western Pacific Meteorology and Climate, September 7-10, 1992, Hong Kong

The Second International Conference on East Asia and Western Pacific Meteorology and Climate, sponsored by the Hong Kong Meteorological Society with support from the University Corporation for Atmospheric Research, will be held September 7-10, 1992 in Hong Kong. The meeting will be organized by an International Organizing Committee with Dr. Bill Kyle (Dept. of Geography & Geology, Univ. of Hong Kong), as the Chairman, and Prof. C.-P. Chang (Dept. of Meteorology, Naval Postgraduate School), as the Vice Chairman.

The purpose of the Conference is to promote the understanding of and to further cooperation in research and applications on meteorology and climate in the region. The first Conference was held at the Royal Observatory, Hong Kong, in July 1989. The Conference will consist of invited and contributed papers in oral and poster sessions where the author is present. Either the Chinese or the English language may be used for presentations. Papers related to either research or operational meteorology have been solicited in the following topic areas: Monsoon Meteorology, Mesoscale Meteorology, Tropical Cyclones, Regional Climate and Climate Change (including effects of human actions), and Applications of New Technologies (especially on weather analysis and forecasting).

NASA CD-ROM from NCDS

Greenhouse Effect Detection Experiment (GEDEX) CD-ROM Released

by Lola M. Olsen and Archibald Warnock III

1992 has been designated as The International Space Year (ISY), the 500th anniversary of the discovery of America by Christopher Columbus and the 35th anniversary of the International Geophysical Year (IGY). The ISY effort is intended to stimulate significant contributions to worldwide scientific research and application activities under the theme "Mission to Planet Earth". The Space Agency Forum on the International Space Year (SAFISY) is responsible for coordinating these activities worldwide.

In preparation for the ISY and in support of SAFISY, the Earth Science and Applications Division of NASA sponsored an initiative, the Greenhouse Effect Detection Experiment (GEDEX), for which a workshop was organized to bring together a core group of scientists to share their research and ideas on the subject of global climate change. Participants in this workshop, which was designated the GEDEX Atmospheric Temperature Workshop, met in Columbia, Maryland, in July 1991 for the purpose of obtaining a measure of progress and to recommend actions required to better understand the global atmospheric temperature record and its relationship with climate forcings and feedbacks. Dr. Robert A. Schiffer and Dr. Sushel Unninayar organized the discussions where concepts and hypotheses were exchanged. A document entitled, "The Detection of Climate Change Due..."
To The Enhanced Greenhouse Effect: A Synthesis of Findings Based on the GEDEX Atmospheric Temperature Workshop, issued by NASA Headquarters in February 1992, summarizes the discussions which took place during the workshop.

One of the primary objectives of the workshop was to identify existing data (focusing on temperature) for the analysis of global climate change and to consolidate selected data sets onto CD-ROMs for distribution nationally and internationally to promote further research. With this focus, Dr. Schiffer requested that NASA's Climate Data System (NCDS) staff prepare for the acquisition, archiving, implementation, and documentation of data recommended for distribution.

GEDEX Data Sets

More than 60 data sets were identified by workshop participants for inclusion, yielding nearly 1 gigabyte of data for this first 2-disk set of CD-ROMs. The data sets include surface, upper air, and/or satellite-derived measurements of temperature, solar irradiance, clouds, greenhouse gases, fluxes, albedo, aerosols, ozone, and water vapour, along with Southern Oscillation Indices and Quasi-Biennial Oscillation statistics. Many of the data sets provide global coverage. The spatial resolutions vary from zonal to 2.5 degree grids. Some surface station data sets span more than 100 years. Most of the satellite-derived data sets cover only the most recent 12 years. Temporal resolution, for most data sets, is monthly. The first disk contains temperature, solar irradiance, cloud, and radiation budget data. The atmospheric constituent data are on the second disk. The data sets, thoroughly documented by standard detailed catalogues, are easily identified through the use of summaries which provide temporal coverage and resolution, spatial coverage and resolution, parameters, and so on.

Disk 1 - Temperature, Radiation and Cloud Data

Temperature - Surface

The basic surface station temperature data set from NCDC/NCAR contains monthly temperature and precipitation values and is subdivided by continent. A few records date from as early as 1738, and modern station data extend through 1989. Other surface temperature anomaly data sets containing monthly gridded values were provided by Philip Jones, University of East Anglia Climate Research Unit, and by James Hansen, Goddard Institute for Space Studies (GISS). Zonal and station temperature data are included from the State Hydrologic Institute's (Russia) Konstantin Vinnikov. These data sets extend over 100 years of record. Gridded 2.5 degree monthly sea surface temperature data and anomalies as calculated by Richard Reynolds from NOAA's Climate Analysis Center also reside on this disk. These SST values are from AVHRR sensors on NOAA polar orbiters and are blended with ship and buoy data. Investigating the effect of the El Nino/Southern Oscillation (ENSO) on the temperature anomaly record, may be done with the data set provided by the University of East Anglia's Climate Research Unit containing the Southern Oscillation Index calculations, along with the Tahiti and Darwin mean sea level pressures from which they are derived.

Solar Irradiance and Transmission

Solar transmission and surface-measured irradiance data were supplied by Ellsworth Dutton, NOAA Climate Monitoring and Diagnostics Laboratory (CMDL). The daily solar transmission indices from the Mauna Loa Observatory begin in 1958 and continue through 1990. The hourly solar irradiance data make up a rare collection of solar data collected at the surface from 1976 to 1989 at selected sites. NASA Goddard Space Flight Center’s Lee Kyle provided solar irradiance data from the Nimbus-7 Earth Radiation Budget (ERB) instrument, and
Langley Research Center's Robert Lee, offered the solar irradiance data from NOAA-9, NOAA-10, and ERBS. Richard Willson of JPL has collaborated with the NCDS staff over the years in making 9 years of solar irradiance data from the Solar Maximum Mission's ACRIM sensor available to users online. The Dominion Radio Astrophysical Observatory (DRAO) (formerly Ottawa) 2800 MHz radio flux data from 1947 to the present are also available on the disk with observed, absolute, and adjusted variables.

Radiation Budget and Clouds

Bruce Barkstrom of Langley Research Center provided the Earth Radiation Budget Experiment's (ERBE S4) combined satellite gridded products, including the scanner data at 2.5 degree resolution and the wide-field-of-view monthly averages. William Rossow, NASA GISS, suggested and subsequently provided a comprehensive subset of the International Satellite Cloud Climatology Project's (ISCCP) monthly cloud products at 2.5 degree resolution. He also assisted in the review and verification of those data. Goddard's Lee Kyle worked closely with the staff in the validation of data on the disk from the Earth Radiation Budget instrument on board Nimbus-7. Data from the wide-field-of-view sensor span the period 1978 to 1987 and are monthly in temporal resolution and approximately 4.5 by 5 degrees in spatial resolution. Goddard's Joel Susskind also worked closely with the NCDS staff, making subsets of his cloud and radiation data available for the disk. His data are derived from NOAA Polar Orbiting satellites using TOVS-HIRS and TOVS-MSU sensors.

Disk 2 - Atmospheric Constituents

The Carbon Dioxide Information Analysis Center (CDIAC), Department of Energy, is the source for the "TRENDS '90, A Compendium of Data on Global Change," providing carbon dioxide and methane values spanning the geological record (through ice core techniques) and more recent values collected by NOAA from flask sampling and continuous monitoring techniques. NOAA ARL's James Angell also contributed seasonal layer ozone data from Umkehr sounding and ozone sonde from 1957 to 1990 and total ozone from Dobson spectrophotometers for the period 1967 to 1989. Patrick McCormick's colleagues at NASA's Langley Research Center worked closely with our staff in providing ozone, nitrogen dioxide, and aerosol data from the Atmospheric Explorer Mission's SAGE I instrument, and aerosol, ozone, water vapor, and nitrogen dioxide data from the Earth Radiation Budget Satellite's (ERBS) SAGE II instrument beginning with data from the November 1984 launch through 1991.

The CD-ROM Design

The intention of the CD-ROM design was to deliver a standalone, operating system independent package to the researcher: data for research, software tools to access the data, and complete documentation. The CD-ROM medium is ideally suited to this purpose. The large (approximately 650 megabytes) capacity, low cost and portable directory structure as enforced by the ISO-9660 specification, make it possible to inexpensively deliver large quantities of data to the end user for use on virtually every computer in use today.

While ISO-9660 defines a platform-independent directory structure and file naming scheme for CD-ROMs, it imposes no requirements on the contents of the files. In order to make data accessible under any operating system, the data must be written in a way which is also independent of the host system. The Common Data Format (CDF) was selected for its advantages in representing the types of data structures found in various kinds of climate data. Gridded data maps naturally to the capabilities of CDF, and the format allows for easy storage of attribute information along with data. In addition, a software library for CDF data runs under several operating systems (Unix, VMS and MS-DOS) and provides for system-independent encoding of the data. This well-defined representation of the data ensures consistent access to the data.

Software

The access software provided on the disk allows the user to browse a table of contents to the disk and to view the summary and detailed information on the individual data sets. Additional software, developed by the CDF staff, provides browse and subsetting capabilities. The software runs with the same user interface under all three target operating systems. The overall user interface was designed to look and perform like the current NCDS online system. The interface in the current release is character-based but could easily be ported to standard windowing environments.

GEDEX Research

The hope is that through this consolidation and documentation of existing data sets, ambiguities and uncertainties associated with climate change and greenhouse gas effect will be further explored.
by more scientists. It is also hoped that researchers will continue to review the relationships between temperature change and plausible cause-effect factors and that these disks will serve as a test-bed for future CD-ROMs for EOS. Support for this effort from the Earth Science and Applications Division, NASA Headquarters was provided by Dr. Robert Schiffer.

If you are interested in receiving a copy of the GEDEX CD-ROM, please contact the Goddard Distributed Active Archive Center (DAAC) User Support Office [NCDS has become part of the Goddard DAAC] by phone: (301) 286-3209, via Internet: NCDSUSO@NSSDCA.GSFC.NASA.GOV or by mail: NCDS/Goddard Distributed Active Archive Center, Code 935, Goddard Space Flight Center, Greenbelt, Maryland 20771.

End of Mission Statement - Second Airborne Arctic Stratospheric Expedition (AASE-II)

NASA Press Release

P.A. Newman April 30, 1992
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Part One: Preamble

This statement has been prepared by scientists of the second Airborne Arctic Stratospheric Expedition (AASE-II). The mission was staged over a period of eight months from Moffett Field, California; Fairbanks, Alaska; Anchorage, Alaska; Stavanger, Norway; and Bangor, Maine. The mission used two aircraft to study the lower stratosphere: a high altitude ER-2 aircraft for in situ observations and a long-range DC-8 for remote sensing observations. This summary represents the preliminary conclusions of the scientists at the end of the flight series.

The issue of ozone depletion is of widespread public concern. Hence, policymakers and the public should be kept abreast of the advances in scientific understanding. It is in this spirit that we report our provisional interpretation of new data concerning stratospheric ozone in the Northern Hemisphere. A comprehensive interpretation of our findings will be forthcoming after a series of scientific meetings and the publication of peer-reviewed scientific papers.

Background to the Mission

In 1985, a large and unanticipated decrease in the abundance of ozone over Antarctica was reported by the British Antarctic Survey. Public concern was heightened in 1988 and again in 1991 by ground and satellite observations that showed ozone at northern mid latitudes in the winter had decreased 6-8% between 1979 and 1990. It is critical to recognize that while ozone exhibits considerable natural variability, decreases in ozone overhead without other offsetting atmospheric changes result in increased ultraviolet radiation reaching the Earth's surface. Biological and medical studies suggest that the accumulated exposure to these increases produce deleterious effects on mankind and other living organisms.

Predicting ozone loss in the Earth's stratosphere over the next decade requires detailed knowledge of both chemical and transport processes. Two types of scientific investigation provide guidance for policy decisions: (1) mechanistic studies linking cause and effect, which serve as the foundation of our ability to look forward in time, and (2) global-scale studies of trends of atmospheric change. Improved understanding of mechanism and process was the focus of the second Airborne Arctic Stratospheric Expedition (AASE-II).

The research phase described here, which began in August, 1991, is a continuation of episodic aircraft flights into the Antarctic, Arctic and mid-latitude stratosphere. More than one hundred flights have been made during the last five years by the ER-2 and DC-8, encompassing all latitudes from the South Pole to the North Pole. Results from the first of these aircraft campaigns, the Airborne Antarctic Ozone Experiment (AAOE) over Antarctica in 1987, demonstrated that chlorofluorocarbons (CFCs) released into the atmosphere caused dramatic springtime ozone erosion over the Antarctic. Those studies pinpointed chlorine monoxide and bromine monoxide as the species responsible for controlling the rate of ozone destruction and further indicated the importance of polar stratospheric clouds (PSCs) in producing chemical transformations that facilitate such destruction. In 1989, the first Airborne Arctic Stratospheric Expedition (AASE-I) was staged from Stavanger, Norway. During that mission, ER-2 flights into the arctic stratosphere revealed that chlorine monoxide and bromine monoxide were present at concentrations comparable to those observed over Antarctica in 1987. However, since the degree of ozone loss depends both on the CIO/BrO concentrations and on the
duration of the elevated levels, the shorter period of cold temperatures in the Arctic diminishes the impact on ozone.

AASE-II is comprised of four major program elements: a high altitude ER-2 aircraft, a long-range DC-8 aircraft, extensive meteorological predictions and analyses, which include an array of computational programs to correlate and interpret the aircraft observations, and finally, the Total Ozone Mapping Spectrometer (TOMS) on the Nimbus-7 satellite, which monitored the global distribution of total ozone. The instrument packages on the two aircraft measured an array of the chemical species and other atmospheric parameters that are associated with the mechanisms that determine the distribution of ozone.

Meteorological analyses from the NOAA National Meteorological Center (NMC) provided the historical context, analysis and predictive capability for temperature, pressure and wind fields for the northern hemisphere during the field deployment.

Three questions define the principal mission objectives for AASE-II:

1. Will significant erosion of stratospheric ozone occur over the Arctic as stratospheric chlorine levels increase during the next decade?

2. What are the causes of mid-latitude stratospheric ozone decreases in late fall through early summer, revealed over the past decade by ground and satellite observations?

Finally, given the eruption of Mt. Pinatubo in June of 1991, we address a another issue:

3. What effect do volcanoes have on the chemical processes that govern stratospheric ozone? In particular, could volcanic aerosols modify depletion of stratospheric ozone associated with industrial halocarbons?

Part Two: Summary Statement

The chemical composition of the stratosphere was highly perturbed at northern latitudes this winter. Most of the chlorine released from CFCs in the stratosphere, where it resides as chemically stable inorganic chlorine (HCl and ClONO₂), was converted to the reactive form (ClO). This transformation, observed in a sequence of flights, began in mid-December and was complete by mid-January. Concentrations of ClO were observed by the ER-2 to increase during January, exceeding 1500 pptv on January 20th. Appearance of high ClO concentrations correlated with the disappearance of HCl and with the onset of temperatures cold enough to form polar stratospheric clouds (PSCs). The onset of cold temperatures, high ClO, and the loss of HCl had been predicted based on laboratory measurements and was observed simultaneously in specific air masses for the first time in AASE-II.

Meteorological conditions over the Arctic this winter were characterized by a period from mid-December to the third week of January when minimum temperatures dropped below the threshold for PSC formation at ER-2 altitudes. This period was shorter than average. An analysis of HCl, ClONO₂, NO, NO₂, HONO₂, and ClO concentrations from this mission, in the context of more than one hundred aircraft flights over the last five years, implies that ClO levels in excess of 1000 pptv should emerge at high latitudes in January during typical or colder years for the next two decades.

Temperatures warmed abruptly within the vortex the third week of January. The decline of ClO commenced as expected when temperatures warmed above the PSC threshold. ClO dropped slowly: by mid-February concentrations from 700 to 1000 pptv were typical in the vortex. The decline of ClO continued into late March.

Calculations based on the observed concentrations of HCl, ClONO₂, NO, NO₂, HONO₂, ClO and BrO in the arctic vortex in January and February indicate approximately 20% ozone removal between 15 and 20 km. Using data for ozone and tracers from the aircraft, evidence for comparable ozone removal was observed over a more limited altitude range. The percentage total column ozone loss is estimated to be about one half the percentage observed between 15 and 20 km. In the calculations, ozone removal is due in about equal measure to reactions involving chlorine and bromine.

The amount of ozone destroyed in a given year is controlled by two factors: (1) total chlorine and bromine concentrations in the stratosphere, both of which are increasing annually; (2) the timing and vertical extent of temperatures below the threshold for PSCs. If temperatures had remained cold into the third week of February, which has occurred several times in the last decade, greater amounts of ozone would have been destroyed. The loss of ozone in winter 1991/1992, while significant, should not be described as an "ozone hole," a term coined to denote the sharp transition to dramatically suppressed O₃ levels over Antarctica. In this hemisphere, it is essential to focus on the more
broadly distributed erosion of ozone at both mid
and high latitudes.

During 1992, the Total Ozone Mapping
Spectrometer (TOMS) satellite measurements
show that the hemispheric ozone average during
January, February, and most of March was lower
than any previous year in the TOMS record.
TOMS measurements also showed that total
ozone values in the mid-latitude maximum during
February were 10-15% lower than any previous
year in the TOMS record. The processes
responsible for this ozone decrease are under
investigation.

The mission revealed strong evidence for the
influence of sulfate aerosols on stratospheric
chemistry, particularly outside the polar vortex.
Natural sulfate particles appear to suppress
concentrations of NO and NO₂, leading to
enhanced concentrations of CIO and BrO. The
highest concentrations of CIO and BrO outside
the vortex were observed in winter at high
latitudes. The results are consistent with the
view, expressed in the recent UNEP report, that
CIO and BrO are likely to be implicated in recent
reductions of column ozone amounts observed
over midlatitudes. The largest changes in
midlatitude ozone levels are observed in late
winter and occur in the same altitude regions
where CIO and BrO are elevated throughout the
winter.

The eruption of Mt. Pinatubo increased
abundances of natural sulfate aerosol particles,
potentially amplifying the effects of reactions
which take place on the surfaces of particles. No
significant direct injection of chlorine by the
volcano was observed. There was no evidence
for significant influence of Pinatubo aerosols on
the chemistry of the polar vortex. In the vortex,
the removal of NO, NO₂, and HCl, and the large
enhancements of CIO appear to be triggered by
formation of PSCs.

Enhanced sulfate loading from Mt. Pinatubo may
affect regions of the atmosphere where the
fractional conversion resulting from pre-Pinatubo
aerosol loading is incomplete, which is
increasingly true at lower latitudes and at altitudes
above 20 km. Column amounts of NO₃ were
observed by the DC-8 to be notably depressed at
mid-latitudes this year, as compared to past years.
Ozone levels were reduced within the Pinatubo
aerosol layers in the tropics.

Part Three: Mission Results

Results from this mission are presented in a
question and answer format and are drawn from
observational data, diagnostic calculations, and an
extensive analysis of the region's meteorology.
Four sections address, in order: the approach to
quantifying ozone loss, mission results obtained
at Arctic latitudes, issues surrounding the
thinning of ozone at mid-latitudes, and finally, the
process used to establish the conclusions cited in
this briefing.

General Approach

(1) How did this mission seek to determine and
understand ozone losses?

The natural abundance of ozone varies with
altitude, latitude, and season, reflecting patterns
in chemical production and loss, and dynamical
transport of ozone. Measurements of O₃ alone are
not sufficient to define the degree of chemical
destruction within a specific region. This is
particularly true in the middle and high latitudes
of the northern hemisphere, where the natural
variability of ozone is very large. Hence, this
mission has utilized four complementary
approaches for diagnosing ozone loss:

Simultaneous, in situ observations of ozone,
winds and atmospheric chemical tracers (N₂O,
CFC-11, CH₃), combined with global maps from
the NOAA National Meteorological Center
(NMC) of stratospheric circulation patterns along
with computed dynamical tracers and air parcel
trajectories. The in situ observations and global
analyses provide the information to define the
atmospheric motion. Research over the past five
years has demonstrated the importance of placing
ozone observations in an analytical framework,
whereby ozone changes resulting from
atmospheric motion can be differentiated from
chemical loss.

Observations of chemical species both directly
responsible for ozone destruction in the
stratosphere (CIO, BrO, and NO₂), and indirectly
responsible (HCl, ClONO₂, HONO₂, H₂O, total
reactive nitrogen) through linking chemical
reactions. Studies in the Antarctic have shown
that CIO and BrO concentrations determine the
rate of catalytic ozone loss within the airmass in
which they are measured. Laboratory studies
provide fundamental data defining chemical
reaction rates, absorption cross-sections, and
molecular structures.

Global maps of total ozone by the Total Ozone
Mapping Spectrometer (TOMS) on board the
Nimbus-7 satellite. A comparison of
measurements taken during this mission with
established historical values of ozone developed
for the northern hemisphere over the 13-year
lifetime of TOMS provides insight into the global distribution of ozone change.

Vertical cross sections of ozone and aerosols from the Differential Absorption Lidar (DIAL) aboard the DC-8 aircraft. The aircraft was used to search for regions inside the vortex with unusual vertical profiles of ozone that might suggest correlation between ozone loss and either the Pinatubo aerosol or polar stratospheric clouds (PSCs).

**Arctic Latitudes:**

(2) What did the mission reveal concerning the chemical composition of the Arctic lower stratosphere?

These studies, in conjunction with the AASE-I investigation of the arctic vortex in January and February of 1989, demonstrate that the conversion of inorganic chlorine (HCl and ClO\(_2\)) to ClO does not require unusual conditions. We believe that ClO mixing ratios exceeding 1000 parts per trillion by volume (pptv) will emerge annually by mid-January throughout the lower stratospheric vortex, except during unusually warm years.

Through the course of twenty-five ER-2 flights and nineteen DC-8 flights, encompassing latitudes from the southern tropics to the pole, the seasonal evolution in concentration of the reactive radicals ClO, BrO, and NO, and of the less reactive chlorine reservoirs, HCl and ClO\(_2\), has been observed from the fall, prior to PSC formation, through winter to the beginning of spring.

The dramatic changes observed in the chlorine composition of the arctic lower stratosphere may be divided into three phases:

(i) Prior to and during the onset of PSCs: At high latitudes, ClO was in the range of 30-50 pptv in October and increased to 130 pptv (at northern latitudes) in mid-December. These values are significantly greater than expected, based on models that do not take proper account of reactions on aerosols. In situ measurements of HCl are lower than expected from model calculations (even those with aerosol reactions) throughout the period.

(ii) Winter occurrence of PSCs: After the onset of PSC temperatures, ClO increased to 500 pptv in the vortex in mid-December. Conversion of inorganic chlorine to ClO was observed inside the vortex by the ER-2 in December, 1991, and January, 1992, as large losses in HCl (reductions of as much as 1000 pptv) occurring simultaneous-

ly with large increases in ClO. In early January, ClO levels regularly approached 1000 pptv, increasing to 1500 pptv by the third week. These ClO levels represent a large fraction of the available inorganic chlorine in the stratosphere and are the highest values observed by the ER-2 in either hemisphere. Using back trajectory analysis, air parcels with low levels of HCl and high levels of ClO were found to have experienced temperatures at or below those required for PSC formation within a few days prior to sampling. Conversely, air parcels showing no evidence of chlorine conversion had not recently experienced PSC formation temperatures. Column measurements of HCl and ClO\(_2\) from the DC-8 were low inside the vortex, with a maximum ClO\(_2\) amount at the edge of the vortex in January. In January and February, 1992, there was little evidence for the irreversible removal of total reactive nitrogen, NO\(_2\) = HNO\(_3\) + N\(_2\)O\(_5\) + NO\(_3\) + NO\(_2\) + NO.

(iii) Disappearance of PSCs: Following a minor warming event in late January, temperatures rose above the PSC threshold and high ClO concentrations at ER-2 altitudes began to decline just inside the vortex, approaching 1000 pptv by mid February, and dropping to 200 pptv by late March. With the decrease in ClO after the cessation of PSCs, HCl and ClO\(_2\) were observed to increase, the latter more rapidly. The springtime decline of ClO and the resulting formation of ClO\(_2\) arises from the increased production of NO\(_2\) from nitric acid released from PSCs as sunlight returns.

Concentrations of BrO between 4 and 8 pptv, accounting for 20-40% of the total inorganic bromine, were observed. These concentrations were not significantly affected by the occurrence of PSCs, nor did they vary significantly throughout the period of observation.

In situ observations of NO were combined with those of ozone and ClO to estimate NO\(_2\) (= NO + NO\(_2\)) in sampled air parcels. The value of NO\(_2\)/NO\(_2\) is used as an index of partitioning within the NO\(_2\) reservoir. Throughout the mission, when ClO levels were elevated, NO\(_2\)/NO\(_2\) values were suppressed at high latitudes. The depletion of NO and NO\(_2\) within the NO\(_2\) reservoir is consistent with low photolysis rates of nitric acid at high latitudes in conjunction with the conversion of NO\(_2\) to nitric acid, via surface reactions on aerosols.

(3) What is the evidence for ozone loss in the Arctic?
Ozone loss was analyzed in the vortex for altitudes below 20 km. Calculations based on the observed time evolution of ClO, BrO, HCl, ClONO₂, NO and NO₂ in the vortex in January and February predict ozone losses of approximately 20% between 15 and 20 km, consistent with observed ozone and tracer data obtained by the aircraft. The magnitude of total ozone loss was limited by the brevity and timing of the period during which temperatures remained below the PSC threshold (-78°C). These losses are quite significant but should not be described as an ozone hole.

Historical observations of the seasonal cycle in polar ozone indicate that from October through March, descent of ozone-rich air in the vortex substantially increases ozone in the lower polar stratosphere, particularly in the 15-20 km region. Changes in ozone at a particular altitude represent a balance between: (a) increases resulting from an influx of ozone from lower latitudes and higher altitudes, and (b) losses due to chemical destruction. Observations of ozone, referenced to both the H₂O and CFC-11 tracer fields, indicate net local decreases of ozone of about 20% in the 16-17 km range, while the balance at higher altitudes results in a small net increase in ozone. Although these results are preliminary, they are consistent with model calculations and with the DC-8 observations between 15 and 18 km.

Simultaneous observations of O₃, ClO, BrO and total reactive nitrogen (NO) in the Antarctic vortex during the period of rapid ozone erosion in 1987 established the relationship between chlorine monoxide and bromine monoxide concentrations and the rate of ozone loss. The AASE-II series of ER-2 flights detailed the time evolution of ClO and BrO concentrations within the Arctic vortex from early January through mid-March. Using ozone destruction rates derived from Antarctic analysis, calculations based on AASE-II data predict ozone losses of approximately 20% between 15 and 20 km altitude, consistent with observations. The amount of ozone lost from the total column depends upon the vertical extent of the amplified ClO/BrO concentrations. Calculations suggest that the total ozone column decreases by approximately half the percentage change that occurs between 15 and 20 km. Calculations guided by the simultaneous observation of ClO, BrO, HCl, ClONO₂, NO and NO₂ during January through March also predict that more ozone loss would have occurred if the period over which temperatures remained below the PSC threshold (-78°C) extended well into February, as they have in approximately half of the last ten years.

4) How did the meteorological conditions of the 1991/92 Arctic vortex compare with those of previous years?

Global meteorological analyses show that the period of cold temperatures (specifically, temperatures below the nitric acid trihydrate (NAT) phase transition at -78°C, allowing PSC formation) was significantly shorter than normal at and below ER-2 cruise altitude.

Temperatures obtained from the NOAA National Meteorological Center were used to determine the climatology of the Northern Hemisphere. As during most northern winters, stratospheric temperatures in 1991/92 were cold enough for formation of PSCs but were not cold enough for extensive water ice particle formation. During a 39-day period from mid-December to mid-January, temperatures were intermittently low enough to form PSCs at the 20 km level. A minor stratospheric warming in mid-January raised temperatures above the PSC limit. This 39-day period contrasts with a 79-day period in 1988/89, and a 68-day range during an average winter.

The stratospheric polar vortex developed in early fall and reached maximum intensity in mid-winter. The 1991/92 polar vortex was not unusually strong, but did persist for an unusually long period (early April). The years 1985/86, 1987/88, 1989/90, and 1991/92 were each characterized by a persistent polar vortex.

(5) Did the presence of Mt. Pinatubo aerosol have significant impact on the chemical composition of the polar vortex?

The abundance of reactive chlorine in the Arctic vortex was dominated by reactions occurring on PSCs, rather than by reactions on either volcanic or background sulfate aerosols. The high abundances of ClO (in excess of 500 pptv) are linked to the advent of PSCs. Trajectory studies (the tracing of airmass motion backward in time from the point of observation by the ER-2) reveal that airmasses characterized by (i) very high concentration of ClO, (ii) nearly complete removal of HCl, and (iii) changes in the particle size distribution, were several days earlier within regions characterized by temperatures below the PSC formation threshold. Trajectory analyses of immediately adjoining airmasses that showed no such perturbations in ClO, HCl, or particle size distribution indicated that these airmasses were not within regions with temperatures below the PSC formation threshold. While we believe that reactions on liquid aerosols are important, conversion of inorganic chlorine (HCl and
CIONO$_2$ to CIO on PSCs is substantially faster, masking any reactions on background aerosols. This conclusion holds even for surface area enhancements of a factor of 30, characteristic of the Mt. Pinatubo cloud.

Lidar observations from the DC-8 showed that the Pinatubo aerosols were concentrated at and below the typical ER-2 flight altitudes inside most of the vortex. The ER-2 encountered the main aerosol layer from Pinatubo at the lowest altitudes in the descent profiles within the vortex. Pinatubo aerosols at high altitudes (up to 26 km) did not reach northern high latitudes soon enough to be entrained within the vortex upon its formation in early winter.

Air outside of the vortex was observed by the DC-8 instruments to move through cold regions, in which both NAT and ice clouds were forming. This air, with only brief exposure time to PSCs, was highly depleted in HONO, CIONO$_2$, and HCl. Air that had moved only through warmer regions of the Pinatubo cloud exhibited near-normal mid-latitude abundances of HONO, CIONO$_2$, and HCl. These observations not only show that PSCs are more important for processing the air than are warm volcanic clouds, but also that a single rather brief exposure to PSCs is capable of significantly processing the air.

(6) Are future arctic ozone losses likely?

Analysis of results from both Arctic airborne missions, AASE-I in 1989 and AASE-II in 1991/92, have isolated two key variables that determine the amount of ozone destroyed in any given year. The first is the amount of chlorine and bromine present in the stratosphere. The second is the timing and vertical extent over which temperatures in the vortex remain below the PSC threshold (-78°C).

The two AASE missions have demonstrated that a large fraction of all inorganic chlorine (HCl and CIONO$_2$) in the stratosphere is converted to CIO and its dimer whenever the temperature in a particular region of the vortex reaches the PSC threshold (-78°C). Therefore, the concentration of reactive chlorine following PSC processing is proportional to total chlorine loading. Additionally, in the absence of NO$_2$, reactive bromine is proportional to the bromine loading. Knowledge of the CIO and BrO concentrations within the vortex allows the determination of the rate of ozone loss.

These missions in conjunction with the Antarctic mission in 1987 have further demonstrated that the total amount of ozone lost in the vortex in any given year (for which the total chlorine and bromine loading are specified) depends foremost on the timing and vertical extent of temperatures within the vortex that remain below the PSC threshold (-78°C). The reason is at least twofold: (i) PSCs retain nitric acid, preventing the reintroduction of NO$_2$, which converts CIO back to the more stable form of chlorine, CIONO$_2$; and (ii) PSCs recycle HCl and CIONO$_2$ back into CIO. The amount of ozone removed is sensitive to the amount of NO$_2$ reintroduced because CIO is removed primarily by reaction with NO$_2$ to form CIONO$_2$. For example, at a current total chlorine loading of 3500 pptv, if vortex temperatures remain below PSC threshold until the fourth week of January, calculations consistent with observed levels of HCl, CIO, BrO, NO, NO$_2$, CIONO$_2$ and HONO$_2$ predict that approximately 20% of the ozone will be destroyed by the chlorine and bromine cycles at ER-2 altitudes. The impact on total column ozone depends upon the vertical extent of the cold region and for typical temperature profiles ranges from one quarter to one half the fractional loss at ER-2 altitudes. If in future years temperatures remain below PSC threshold until the fourth week of February, a circumstance that has occurred a number of times in the last decade, ozone loss will increase substantially.

Mid Latitudes

(7) What did the mission reveal concerning the chemical composition of the mid-latitude stratosphere?

The mission revealed strong evidence for the influence of sulfate aerosols on stratospheric chemistry from several new, independent sets of measurements. These include:

- CIO abundances near 20 km that are a few times larger than gas-phase chemical model predictions but in broad agreement with models including surface reactions of N$_2$O$_5$ on sulfate aerosols.
- Observations that NO concentrations are many times smaller than gas-phase chemical model predictions, again in broad agreement with models including surface reactions on sulfate aerosols.

In addition to their absolute values, both the seasonal and latitudinal variations observed in CIO and NO conflict with gas-phase model predictions but are consistent with our understanding of the impact of sulfate aerosols. In particular, the CIO increased substantially...
from summer to winter, in direct contradiction to gas-phase chemistry.

Observations of NO\textsubscript{2} column abundances that are significantly lower than those obtained in 1989 under comparable conditions.

This suggests important effects from the added sulfate aerosols present in the stratosphere this year due to the eruption of Mt. Pinatubo, notably an increased altitude range over which heterogeneous processes convert NO\textsubscript{2} to nitric acid and a resulting increase in ClO.

The mission also provided important information on the abundances, trends, and origin of stratospheric chlorine, bromine, and fluorine.

Measurements of long-lived tracers show that the total chlorine and total bromine entering the tropical lower stratosphere is about 3.5 ppbv and 20 pptv, respectively, of which 2.9 ppbv of chlorine and about 8 pptv of bromine are manmade. In addition, column measurements of HF and HCl, made in 1989 and 1991, suggest that stratospheric fluorine and chlorine have been increasing by about 10% and 5% per year, respectively, consistent with releases of manmade compounds.

(8) What does the Total Ozone Mapping Spectrometer (TOMS) show with respect to this year's ozone distribution?

During 1992, TOMS measurements show that the hemispheric ozone average during January, February and most of March was lower than any previous year in the TOMS record. TOMS measurements also showed that total ozone values in the mid-latitude maximum were 10-15% lower compared to previous years. The mechanisms responsible for this reduction in ozone are currently under study.

To date in 1992, TOMS measurements show that the hemispheric ozone averages were as low or lower than any previous year in the TOMS record. However, the very lowest values of total ozone were similar to those found in previous years.

(9) To what extent do the results of this mission contribute to our understanding of the observed long-term decrease of mid-latitude ozone?

The results from this mission, particularly the observations of HCl, NO, NO\textsubscript{2}, ClO, BrO and the tracers N\textsubscript{2}O and CFC-11, support the conclusion, stated in the recent UNEP Report, that decreases in ozone are associated with increases in chlorine and bromine in the lower stratosphere.

Ozone changes at mid latitudes result from the combined influence of (i) chemical loss by chlorine, bromine, hydrogen and nitrogen catalytic cycles, and (ii) dynamical redistribution of ozone through the seasonal cycle. Observations of HCl, ClO, BrO, NO, NO\textsubscript{2} and the tracers N\textsubscript{2}O and CFC-11 obtained during AASE-II have defined for the first time the relative importance with respect to ozone loss of the major nitrogen, chlorine and bromine cycles in the lower stratosphere (15-20 km). These observations show that while a number of catalytic cycles contribute to the balance between ozone production and loss in the lower stratosphere, chlorine and bromine reactions have a significant and perhaps dominant role in the ozone loss budget. In addition, observed concentrations of NO, ClO and BrO highlight the critical importance of the bromine cycle to increasing ozone loss rates of ozone at mid latitudes.

Models that are consistent with the simultaneously observed concentrations of HCl, ClO, BrO, NO, NO\textsubscript{2} and ClONO\textsubscript{2} predict long term ozone losses, primarily as a result of reactions involving ClO and BrO. These models are in general agreement with the observed ozone decrease at mid latitudes reported by ground-based and satellite data over the decade of the 1980s. It is important to note that major contributions to the balance between ozone chemical production/loss and dynamical redistribution through the seasonal cycle extend from 15 to 30 km and that the AASE-II results are focussed primarily on the altitude interval from 15 to 20 km.
(10) To what extent was the observed chemical composition in mid latitudes and the tropics influenced by the eruption of Mt. Pinatubo?

The eruption increased the natural abundances of sulfate particles, thereby potentially amplifying the effects of heterogeneous reactions. No evidence has been found for significant chlorine injections. At mid and high latitudes, the chemical perturbation that could be traced to Pinatubo was a suppressed mid-latitude NO$_2$ column concentration. Ozone levels in the tropics also were found to be reduced within the Pinatubo aerosol layers.

The TOMS instrument observed a stratospheric SO$_2$ injection from the eruption of Mt. Pinatubo which exceeded that measured or estimated from any other eruption in the past century. TOMS observed the SO$_2$ to decline quickly as it was converted to sulfuric acid particles. The optical depth (which is proportional to the column surface area of the particles) of the resulting global scale volcanic cloud was found by instruments on the DC-8 to be greater than that of the 1982 El Chichon eruption. The column surface area in the volcanic cloud exceeded the surface area of background aerosols by a factor of about 20 to 40 in the tropics and about 10 to 20 in the Arctic vortex. DC-8 lidar measurements showed that the region of significantly enhanced surface area extended from the local tropopause up to about 26 km in the tropics, to about 22 km at northern mid latitudes, and to about 18 km in the Arctic vortex. ER-2 observations showed that local surface areas were enhanced by factors of 20-30 at mid latitudes over non-volcanic levels. ER-2 and DC-8 particle analyses showed the volcanic cloud was dominated by submicron sized sulfuric acid particles.

Volcanic eruptions can potentially inject significant quantities of chlorine into the stratosphere. Measurements made in the Pinatubo cloud revealed that the eruption could have perturbed stratospheric chlorine levels by more than about 5%, which is the equivalent of about one year’s anthropogenic contribution to rising stratospheric inorganic chlorine levels. Although DC-8 column data do show a 5% yearly rise in inorganic chlorine over the past several years due to the anthropogenic contribution, no measurable contribution to stratospheric chlorine was observed in the dispersed Pinatubo cloud. Likewise, ER-2 measurements of HCl inside and outside of the volcanic cloud at mid latitudes did not show any evidence of enhanced stratospheric chlorine resulting from the Pinatubo eruption. No enhancement in stratospheric water vapor resulting from Mt. Pinatubo was observed.

Numerous theoretical studies have suggested the potential for volcanic eruptions to affect mid-latitude ozone levels. The proposed mechanism involves reactions occurring on the surface of sulfuric acid particles (which deplete NO$_2$). The depleted NO$_2$, in turn, would lead to an increase in ClO through gas phase chemical processes and the ClO would destroy ozone. The reactions depleting NO$_2$ are very efficient even on the background stratospheric aerosols and therefore stratospheric NO$_2$ is not expected to decrease in direct proportion to increased aerosol loading. We found that NO$_2$ columns in the Arctic vortex, although low, were not lower than in 1989. At high latitudes outside the vortex the NO$_2$ column was slightly lower than in 1989. These results are in line with expectations that the volcanic cloud would have little impact on high latitude NO$_2$ levels, which are already driven quite low by background sulfate aerosols. At mid latitudes, column NO$_2$ values were lower than in previous years, reflecting both (i) the increased altitude range over which heterogeneous conversion of NO$_2$ to nitric acid took place within the volcanic cloud, and (ii) the higher concentrations of NO$_2$ (resulting from the faster photolysis rates of nitric acid) at lower latitudes that were thus sensitive to enhanced heterogeneous conversion to nitric acid on aerosol surfaces.

It is not clear whether the volcanic sulfate aerosol, which will be removed from the stratosphere by natural processes over the next few years, will increase the amount of mid-latitude ozone depletion that is expected to occur over this period due to rising inorganic chlorine levels from anthropogenic sources.

The DC-8 lidar measurements in the tropics showed a negative correlation between the presence of the Pinatubo aerosols and ozone levels compared to satellite climatology for that region. The maximum amount of the decrease was about 20% near the center of the Pinatubo layer at 23 km. These results agree with ozone changes across the Pinatubo layer found in ozonesonde data from the tropics.

(11) Have we learned anything new about the impact of aircraft exhaust on the stratosphere?

The importance of heterogeneous reactions on sulfate aerosols has been verified by these aircraft studies. Thus, the impact of additional NO$_2$ on ozone in the lower stratosphere is expected to be much smaller than previously predicted and may now be closer to that simulated with the most recent global assessment models that include heterogeneous sulfate-layer chemistry.
Scientific Process

(12) What was the scientific process involved in coming to the above conclusions?

The above conclusions were based on a group synthesis of the viewpoints of more than 80 scientists involved in the AASE-II campaign. The observations and simulations involved in this mission have built upon a rich research heritage, including updated laboratory kinetic studies of gas and surface reactions. The ER-2 and DC-8 aircraft and many of the instruments have been involved in over a hundred stratospheric research flights. The methods and results are contained in numerous peer-reviewed journal publications including three special issues. The science team included both experimentalists and theorists, whose experience and background embraces chemistry and chemical modelling, physics, meteorology, and large-scale dynamics. In designing the mission and interpreting the data, the efforts of the principal investigators were augmented by an advisory and review group. The details of the results of the current campaign will be published in the peer-reviewed literature.

New Evidence Indicates Global Climate Change May Occur Suddenly

National Science Foundation Press Release

Cheryl Dybas
(202) 357-9498
April 30, 1992
NSF PR 92-46

New Evidence Indicates Global Climate Change May Occur Suddenly

Rapid changes in air and sea temperatures around the North Atlantic caused by sudden shifts in the ocean conveyor belt circulation system that transports heat from the equator towards the poles have been confirmed by National Science Foundation (NSF)-funded scientists at the Woods Hole Oceanographic Institution in Woods Hole, Massachusetts. The temperature and circulation shifts may occur within a period of 40 years, indicating that "greenhouse warming" and the melting of snow and ice at the poles may be far more rapid than previously thought.

Scientists Scott Lehman and Lloyd Keigwin of the Institution's Geology and Geophysics Department presented the new data on the timing, rates and cause of circulation change in the North Atlantic Ocean since the last ice age in a paper published today in Nature. Their findings are based on a study of microscopic animal skeletons and oxygen isotope variations in a sediment core from the Norwegian Trench, an ocean-bottom core with rates of sediment accumulation rapid enough to document these sudden changes. While computer models have suggested that a gradual atmospheric warming over a 100-year period might occur in response to buildup of greenhouse gases in the atmosphere, Lehman and Keigwin's findings suggest that greenhouse-induced melting might lead to sudden circulation changes that could result in dramatic cooling.

"Our results suggest that the present climate system is very delicately poised," Lehman said. "The system could snap suddenly between very different conditions with an abruptness that is scary. It's a strongly non-linear response, meaning shifts could happen very rapidly if conditions are right, and we cannot predict when that will occur. Our studies tell us only that when a shift occurs it could be very sudden."

Oxygen isotope records in ice and sediment cores from the Greenland ice sheet and Lake Gerzensee in Switzerland, and fossil plankton in a sediment core taken west of Ireland in the North Atlantic Ocean, have been used in previous climate change studies. However, typical ocean bottom sediments do not accumulate fast enough to provide sufficient evidence of rapid temperature and circulation shifts, according to Lehman. The new evidence comes from a core called Troll 3.1, taken in the Norwegian Trench. The core was taken in an area where sediments accumulated very rapidly from continental erosion during the last Ice Age.

"Cores with such a long undisturbed record are rarely available to ocean scientists because of the high cost of recovery," Lehman said. Oceanographers normally work with sediment cores 10-20 meters (33-66 feet) long, while cores from the area studied by Lehman and Keigwin are 100-200 meters (328-656 feet) in length. The core was made available to Lehman and Keigwin by Norsk Hydro A/S, an oil exploration firm, which was prospecting for new drilling sites off the Norwegian coast.

Lehman and Keigwin reconstructed sea surface temperatures by looking at planktonic foraminifera -- microscopic shell-forming animals living near the surface of the open ocean -- with known temperature tolerances. Ocean bottom sediments contain the skeletal remains of these animals and have long been used by ocean scientists as indicators of past changes in water
temperature. By counting the different types of shells in the core and plotting them as a function of depth, Lehman and Keigwin noticed many transitions between warm and cold water species. They dated these changes very precisely using a recently developed radiocarbon dating technique - accelerator mass spectrometry - which directly counts carbon-14 atoms in the shells. This data, together with the rapid accumulation rates, permitted Lehman and Keigwin to precisely calculate rates of change.

Scientists have known for some time that during Ice Ages polar species of foraminifera lived much farther to the south, and at these times the Gulf Stream flowed straight across the Atlantic toward Portugal rather than on its present path northward toward Norway. What they didn't know until this study was that similar shifts occurred many times at the close of the last Ice Age, and occurred extraordinarily quickly.

Studies of ice cores from Greenland during the 1980s revealed that large and rapid changes in atmospheric temperature, by approximately seven degrees Celsius (28.80 Fahrenheit) in 50 years, occurred at the end of the last Ice Age some 14-8,000 years ago. Similar shifts appear in ice core records every 5,000 years or so back to approximately 70,000 years ago, and appear to be a characteristic feature of the earth’s climate. Scientists have suggested that the sudden changes in air temperature and ocean circulation patterns were caused by changes in the way the ocean conveyor belt system operates. Lehman and Keigwin’s findings provide a direct evidence of this process.

"The ocean circulation system drives the climate system," Lehman said. "The ocean acts like a conveyor belt, carrying the warm surface water of the Gulf Stream from the equator northward into the North Atlantic and Norwegian Sea. Gulf Stream waters become enriched with salt through the warm latitudes. As this water flows toward the cold Norwegian Sea it releases heat to the atmosphere and becomes dense enough to sink. This new water mass, known as North Atlantic Deep Water, then travels south through the Atlantic, around Africa and through the Indian Ocean into the Pacific like a conveyor belt. New warm surface water is drawn northward to replace this water and the cycle repeats itself. The conveyor system is thus a heat engine."

It was suggested earlier that freshwater input to this system, either from increased precipitation, decreased evaporation or melting of snow and ice, could reduce the salt content in surface waters enough to stop them from sinking, thereby turning off the conveyor system and the northward flow of heat. Lehman and Keigwin’s studies indicate that the Norwegian Sea limb of the conveyer belt was periodically shut down due to inputs of freshwater at the end of the last ice age, leading to sudden shifts in sea and air temperatures.

"If greenhouse warming occurs and leads to increased amounts of precipitation in the Arctic and/or melting of snow and ice, the Norwegian limb of the conveyor might be threatened, leading to very rapid changes in ocean conditions and climate," Lehman notes. "In such a scenario, the present climate of Britain and Norway would change suddenly to that of Greenland and northern Canada."

The National Science Foundation is an independent agency of the United States federal government established in 1950 to promote and advance scientific progress in the United States. NSF accomplishes its mission primarily by competitively awarding grants to educational institutions for research and education in the sciences, mathematics, and engineering.

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Review of winter 1991-92

Important climatological events

Overall the winter continued a return to wetter than normal conditions after the dry trend started to break during the autumn. This return coincided with the establishment of an El Nino event which appears to be as well developed as that of 1982-83. Although December was drier than normal (43%) January and then February were exceptionally wet (171% and 298% of 1961-90 normal respectively). The season also started off warm with mean December temperatures 0.8°C above normal. It was also one of the warmest Christmases on record. However, only three days later an exceptionally intense surge of the northeast monsoon caused temperatures to drop by nearly 20 degrees. January and February were generally cooler than normal with the latter month being particularly dull and gloomy in comparison to the high amounts of sunshine in January which was associated with the dominance of the winter monsoon.

Mean daily temperature 16.5°C (+0.1°C)
Rainfall (provisional) 194.6 mm (197 %)

December

December was relatively humid with a monthly mean wet-bulb temperature of 15.9°C, the ninth highest on record for the month. However, like November, it was another dry month with the monthly total rainfall of 11.8 mm being 57 percent below the 1961-90 normal of 27.3 mm. Although monthly mean temperatures were 0.8°C above normal, December was notable for its exceptional extremes of temperature. The daily minimum (19.6°C), mean (21.2°C), and maximum (24.2°C) temperatures on 25th were respectively the first, second and third highest on record making it one of the warmest Christmas Days on record. In marked contrast, a fall in temperature of nearly 20 degrees over the next three days brought freezing conditions and widespread frost and ice on high ground. The daily mean (6.1°C) and minimum (4.6°C) temperatures recorded on 28th were the second lowest for December while the daily maximum (9.6°C) on 29th was the fourth lowest.

For the first eight days a weak northeast monsoon prevailed with mist patches offshore to the east of Hong Kong at night and in the morning. There was some drizzle overnight early in the month and cloudier conditions on 2nd, 7th and 8th but otherwise the weather was fine and mainly warm. Easterly winds picked up on 7th becoming generally strong offshore on 9th with increasing cloudiness leading to light rain on 10th. During this time the temperature only dropped 2 to 3 degrees and once the winds subsided and the clouds broke on 11th the temperature rose to 25.1°C, the highest for the month. This warm period was short-lived with another easterly airstream arriving in the evening bringing fresh to strong winds and clouds and light rain on 12th. Weak replenishments occurred intermittently between 13th and 24th, during which time the weather was mainly fine. Transient cloud and some drizzle marked 15th and 23rd and there was a brief cooler period on 19th and 20th associated with freshening of the monsoon. A light south easterly arrived on 25th giving a warm Christmas Day, one of the warmest ever recorded in Hong

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A cold front ahead of an intense surge of winter monsoon entered Guangdong on 26th leading to a freshening of easterlies before the onset of northerlies on 27th. Clouds thickened and intermittent light rain occurred with the approach of the front following the passage of which rain became more persistent under overcast skies. During this time strong to gale force northerly winds brought very cold air of polar origin to the coastal areas. On 28th the temperature at the Royal Observatory reached the month's and year's low of 4.6°C. In the New Territories the temperature in the morning of 29th was only a few degrees above freezing and on high ground the rare sight of icicles and frost was commonplace. At Tai Mo Shan the lowest temperature recorded was -4.7°C. During the last few days of the month the surge subsided and temperatures recovered steadily although rainy weather continued until the morning of 31st.

Mean daily temperature 18.4°C (±0.8°C) Rainfall (provisional) 11.8 mm (43 %)

**January**

January was a sunny month with 197.1 hours of bright sunshine, about 30 percent above normal. This reflected the dominance of the winter monsoon circulation which is also seen in the unusually high monthly mean pressure of 1022.2 hPa, the sixth highest on record for January. Despite this pattern, rainfall was also plentiful by January norms (171%) although the vast majority of this fell on 5th during a particularly active winter monsoon spell. Air temperatures for the month were on the whole close to normal.

The year started with the cloudy and rainy weather which ended 1991. Continuous rain started in the afternoon of 1st and persisted for 24 hours after which drizzle continued until heavy rain returned late on 4th following the return of a strong easterly surge that afternoon. With a northerly replenishment the rain grew heavier on 5th with the total of 38.8 mm on that day accounting for 97 percent of the monthly total. Drier air ended the spell that evening producing two fine days on 6th and 7th. Despite a brief strengthening of easterlies in the evening of 7th leading to light rain patches, the northerly dominance resumed on 8th giving sunny periods. Progressive falls in temperature gave a cool day on 9th with intermittent light rain which ceased to give sunny periods on 10th and fine weather on
11th. Cloudiness increased on 12th but the arrival of a dry continental air mass on the morning of 13th meant their gradual dissipation. Strong northerly winds brought cold air to the coast to give the month's low temperature of 8.4°C early on 15th. Ground frost was reported at Ta Kwu Ling, where the minimum dropped to 1°C. As the northerlies subsided moisture built up and a freshening of the easterlies on 18th brought some drizzle that night. Although temperatures continued to gradually rise there was a temporary check by a minor northerly replenishment on 20th which lowered temperatures the next day. An extended lull of the winter monsoon allowed the warm up to continue with mist patches appearing offshore on 21st, 23rd and 24th under the influence of a moderate easterly airstream. With plenty of sunshine the rising temperatures reach a high for the month of 23.1°C on 30th. Mist re-appeared offshore that evening but dry air associated with a northerly surge on the morning of 31st ended the month with a fine day but lower temperatures.

Mean daily temperature 15.7°C (-0.1°C)
Rainfall (provisional) 40.0 mm (171%)

February

February was in sharp contrast to the previous month with dull and damp conditions replacing the bright and sunny skies of January. A prolonged spell of clouds, rain and mist lasted for most of the month, producing only two thirds of normal sunshine amounts. The month was also wet with a total of 142.8 mm being nearly three times the normal of 48 mm. This made the month the sixth wettest February on record.

Winds turned easterly and strengthened on 1st after the arrival of the northerly surge of the winter monsoon at the end of January. Cloudy and windy conditions persisted until the strong easterlies were replaced by a moisture laden maritime airstream on 2nd giving mist offshore on 3rd, 24th and 25th under the influence of a moderate easterly airstream. With plenty of sunshine the rising temperatures reach a high for the month of 23.1°C on 30th. Mist re-appeared offshore that evening but dry air associated with a northerly replenishment on the morning of 31st ended the month with a fine day but lower temperatures.

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Mean daily temperature 15.4°C (-0.5°C)
Rainfall (provisional) 142.8 mm (298%)

Review of spring 1992

Important climatological events

The only other occasion when there was such a wet spring as in 1992 was the record-breaking year of 1983 which also occurred during a well-developed El Nino event in the eastern equatorial Pacific. The seasonal rainfall total of 1336.9 mm was nearly two and half times normal with all three months being unusually wet. March was the second wettest on record with 362 percent of normal rainfall. April's total of 492.2 mm made it the wettest April since records began and May, with 90 percent above normal was the tenth wettest on record. The season was also one of extreme rainfall events. Almost half of March’s rainfall fell on one day, the second wettest March day on record. The 8th May was also the second wettest May day and a new hourly record of
109.9 mm between 6 and 7 a.m. that day broke the previous high set during the exceptional rains of 12 June 1966.

Mean daily temperature 21.6°C (-0.6°C)
Rainfall (provisional) 1336.9 mm (245%)

**March**

The dull, wet weather of February continued through the month. The monthly mean relative humidity reached a high of 90 percent, the highest since 1978 in March. The sunshine duration for the whole month was only 37.6 hours, less than 40 percent of normal and the ninth lowest on record. Rainfall was also plentiful with the monthly total of 242.4 mm being over three and a half times the monthly normal of 66.9 mm. Almost half of this amount fell on 3rd making it the second wettest March day ever.

The month started with rain and mist on 1st. Although the rain lessened the mist thickened the next day. A cold front approaching from Guangdong led to increasingly unstable weather ending in a heavy downpour early on 3rd. Warm maritime air raised temperatures briefly but winds soon freshened to strong northerly after the passage of the front on 4th. The weather became progressively colder under the influence of the northerly airstream reaching a minimum for the month of 9.7°C in the morning of 6th. Although cold, cloudy conditions with light rain continued for the next two days, temperatures began a slow rise as the northerlies subsided. The warming trend continued for the next eight days ending on 16th with the month's high of 25.5°C. Under southeasterlies the 14th was the sunniest day in an otherwise prolonged dull and misty period. Easterly winds again freshened later on 17th bringing cooler weather with patches of light rain. Periods of sunshine appeared on 19th as the easterlies subsided and the next few days were characterized by sunny intervals although mist patches and offshore fog also returned. Another replenishment of easterlies on 21st checked the warming process briefly but they soon subsided and turned southeasterly on 23rd. Warm, moist, maritime air brought widespread mist and fog over the next two days and temperatures rose steadily to a high of 25.5°C, the same as on 16th, in the morning of 26th. Under the influence of a trough of low pressure temperatures dropped around 9°C in urban areas in the late morning as
winds turned northwesterly and heavy rain and squally thunderstorms occurred in the early afternoon. Rain continued on 27th and 28th though not as heavy before a northerly airstream induced a cooling trend through 29th. Sunny periods returned on 30th but winds veered easterly and then southeasterly the next day bringing a further influx of moisture to an already saturated atmosphere and leading to thunderstorms in the afternoon.

Mean daily temperature 18.0°C (-0.5°C)
Rainfall (provisional) 242.4 mm (362%)

April

April continued the wet conditions characteristic of the previous three months with prolonged heavy downpours resulting in the wettest April since records began in 1884. The record high rainfall for the month was 492.2 mm, over 3 times the normal amount. Nearly 97 percent of the total fell in a particularly wet spell lasting from 3rd to 11th when two contrasting air masses, a moist maritime air mass from the South China Sea and a cooler drier one from inland China remained over the coast of Guangdong near Hong Kong generating an extended rainfall event which peaked on 10th with a total of 160.7 mm, the 2nd highest ever recorded for a single day in April. With such a wet month it was not surprising that mean cloud amount was 7 percent more than normal and total duration of sunshine was less than 70 percent of that normally expected in the month. The month was also cool with mean air temperature of 21.9 °C, 0.3°C below normal.

Light rain and fog marked the start of the month with visibility down to 100 metres inside the harbour in the morning. The next day, the fog lifted as easterlies set in and freshened on 3rd to give the month’s low of 17.4°C on that morning. The passage of a band of thunderstorms, during which hail was reported, marked the beginning of an extended period of rain due to the interaction of a moist maritime airstream and replenishment of the northeast monsoon on 7th. Intermittent rain began that morning followed by a major outbreak of squally thunderstorms which brought over 50 mm in the afternoon before the rain died out in the evening. Fresh convective activity developed to the north west of Hong Kong during the night with rain resuming just before daybreak on 8th. Within 3 hours nearly 200 mm had fallen at the Royal Observatory and a new hourly record rainfall of 109.9 mm had been set. After a brief respite a brief fine period for the next three days. Cloud increased again on 17th and rain returned on 18th and 19th as easterlies were replaced by a warm, unstable maritime airstream. During the next four days successive outbreaks of cool easterlies associated with an anticyclone over East China brought clouds and light rain. As the easterlies moderated weather became fine apart from some fog and drizzle in the morning from 24th to 26th. The prolonged sunshine caused temperatures to rise towards the end of the month reaching a high of 29.6°C in the afternoon of 30th.

Mean daily temperature 21.9°C (-0.3°C)
Rainfall (provisional) 492.2 mm (305%)

May

May was another wet month with a total rainfall of 602.3 mm, 90 percent above the 1961-90 normal, making it the 10th wettest May ever. More than half of this amount, 324.1 mm, fell during a very intense storm on 8th, making that day the second wettest May day on record. The hourly rainfall between 6 and 7 a.m. of 109.9 mm produced a new record for hourly rainfall in Hong Kong ahead of that set during the disastrous rainsstorms of 12 June 1966. With cloud and rain dominant the month saw only 93.8 hours of sunshine, the fifth lowest. Temperatures too, were lower as a consequence of the limited solar energy available.

The fine weather of late April extended into May with the temperature climbing above 30°C for the first time in 1992 on 1st. The spell was short-lived, however, with an easterly surge of cooler continental air bringing strong winds and light rain early on 3rd. Although some sunny intervals returned on 4th moist maritime air brought mist and drizzle that night and a short interlude of unsettled weather. The 6th was a fine, sunny day with temperatures reaching a maximum of 31.0°C, the highest recorded during the month. This was to be, however, the prelude to an exceptional rainfall event associated with a trough of low pressure which formed over southern China bring unsettled conditions over the coastal areas on 7th. Intermittent rain began that morning followed by a major outbreak of squally thunderstorms which brought over 50 mm in the afternoon before the rain died out in the evening. Fresh convective activity developed to the north west of Hong Kong during the night with rain resuming just before daybreak on 8th. Within 3 hours nearly 200 mm had fallen at the Royal Observatory and a new hourly record rainfall of 109.9 mm had been set. After a brief respite
around midday another band of thunderstorms swept through so that by the end of the day 324.1 mm had fallen at the Royal Observatory making it the second wettest May day on record. Convective activity, though less intense, affected the coastal areas for the next two days before cooler air north of the trough finally arrived to bring temperatures down to the month’s low of 20.2°C on 10th. Although clouds remained on 11th the next two days were fine and sunny as the easterlies subsided. Intermittent light rain returned on 14th followed by another outbreak of squally thunderstorms and heavy rain in the afternoon of the next day. Light rain persisted on 16th but became heavier the next day as a trough passed across the coastal region. This brought cooler air and some sunny intervals on 18th before clouds and light rain returned for the next few days as the easterlies freshened with another rainy period occurring in the evening of 21st. Light, variable winds brought mainly cloudy weather and light showers until 27th with only 24th being a moderately fine day. Despite a slight freshening of easterlies on 28th it was a fine day before unsettled conditions returned as another trough formed over southern Guangdong. This brought heavy rain and thunderstorms on the afternoon of 30th and after passing over the coast the next day produced some bright intervals to end an otherwise dull and wet month.

Mean daily temperature 24.8°C (-1.1°C)
Rainfall (provisional) 602.3 mm (190 %)
Meeting Reviews

Annual Meeting 1992

Venue: Hillview Hotel, Kowloon

Date: 7 March, 1992

Twenty seven members and two observers participated in the Annual Meeting of the Society held at 12 noon on Saturday 7 March, 1992 at the Hillview Hotel, 13 Observatory Road, Kowloon.

This meeting was held immediately after a brief Extraordinary General Meeting called by the Executive Committee to provide it greater flexibility in scheduling the AGM. To this end two changes needed to be made to the Society’s Constitution. An amendment to Section 7.1 was proposed to allow the AGM to be held any time during the first quarter rather than just in February. This also required a consequent amendment to section 12 to permit that section to be in agreement with Section 7.2 with regard to circulation of notice. Both amendments were accepted by the EGM.

The outgoing Chairman, Dr. Bill Kyle, welcomed members and guests to the AGM and thanked the members of the 1991-92 Executive Committee for their hard work and the members of the Society for their support during the year. He then presented his annual report for 1991-92 which highlighted the following points.

On 29th February, 1992 membership of the Society stood at 173, comprising 101 Fellows, 52 Associate Members, 10 Student Members and 10 Corresponding Members. This total represents an increase of almost 40 percent over the previous year, a good sign of a growing Society. The still small number of Student Members, however, suggests that a drive is needed to recruit and keep this category of membership.

At the AGM on 23 March 1990, an amendment to Section 8.1 of the Society’s constitution was passed so as to increase the number of Executive Committee members from three to five and to include the immediate past Chairman as one of the five members. This worked well to spread the workload of the Committee and to ensure continuity from year to year.

During the year various activities of scientific and technical interest to members and their guests were organized. These included three lectures in the Special Topics Lecture Series, and a Research Forum on the topic of "The Impact of Climate and Climate Change". Two Public Lecture Series, in Cantonese, were also undertaken. The first, jointly organized by the Society and the Hong Kong Space Museum was on the theme "Meteorological Hazards and Climatic Change". The second, jointly organized by the Society and the Hong Kong Science Museum was on "The Science of Weather".

Some members of the Society also contributed papers to "Infrastructure '91: International Workshop on Technology for Hong Kong’s Infrastructure Development", jointly organized by The Hong Kong University of Science and Technology and Hong Kong Science Museum.

During the year two issues of the Hong Kong Meteorological Society Bulletin, Volume 1, Number 2 and Volume 2, Number 1 were published by the Editorial Board.

Lastly an International Organizing Committee was set up during the year to oversee the arrangements for "2nd International Conference on East Asia and Western Pacific Meteorology".
and Climate" to be held in Hong Kong in September 1992. A Local Organizing Committee has also been constituted.

The Hon. Treasurer, Dr. Steve Hsu, then presented the audited accounts of the Society for the year. These were adopted unanimously.

Prior to elections an amendment was proposed to Section 5.1.2 of the constitution so as to extend the bestowal of Honorary Membership in the Society to include institutions as well as individuals. The amendment was adopted.

Election of Office Bearers of the Society, and appointment of the Honorary Legal Advisor and Honorary Auditor produced the following results:

Chairman: Dr. W.J. Kyle
Vice-Chairman: Dr. S.C. Kot
Hon. Secretary: Mr. E.S.T. Lai
Hon. Treasurer: Mr. Y.K. Chan
Committee: Dr. J.C.L. Chan, Dr. S.I. Hsu, Mr. C.Y. Lam, Dr. G.R. McGregor, Mr. Y.S. Sin

Hon. Legal Advisor: Ms. Venus Choy
Hon. Auditor: Mr. J.C.T. Wu

The meeting agreed to continue waiver of the Entry Fee for all those who submit their application to join the Society in 1992-93 as this policy encouraged growth in membership. The following annual subscriptions were also adopted:

HK$150 for Fellow
HK$100 for Associate Member
HK$50 for Student Member
US$20 for Corresponding Member
HK$500 for Institutional Member

Two papers were delivered in the first session as listed.

APPLICATIONS OF INFRA-RED AND VISIBLE IMAGES FROM GEOSTATIONARY METEOROLOGICAL SATELLITES
by Dr. Andrew Cheng, Department of Applied Science, City Polytechnic of Hong Kong

APPLICATIONS OF NEURAL NETWORKS IN THE ANALYSIS OF SATELLITE IMAGES
by Mr. Victor Lee, Department of Applied Science, City Polytechnic of Hong Kong

Following a break for refreshments two more papers were delivered in a second session as listed.

PHASED ARRAY DOPPLER ACOUSTIC RADAR
by Dr. S.C. Kot, Department of Mechanical Engineering, The Hong Kong University of Science and Technology

APPLICATION OF FUZZY LOGIC AND EXPERT SYSTEMS IN METEOROLOGY
by Dr. Y. Leung, Department of Geography, The Chinese University of Hong Kong

Research Forum 4

Venue: Hillview Hotel, Kowloon
Date: 7 March, 1992
Subject: Remote Sensing

A fifth research forum was held at the Hillview Hotel, Kowloon with the theme of Remote Sensing. The forum was organized by Dr. S.L. Hung of the City Polytechnic of Hong Kong who also chaired both sessions.

Two papers were delivered in the first session as listed.

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APPLICATIONS OF NEURAL NETWORKS IN THE ANALYSIS OF SATELLITE IMAGES
by Mr. Victor Lee, Department of Applied Science, City Polytechnic of Hong Kong

Following a break for refreshments two more papers were delivered in a second session as listed.

PHASED ARRAY DOPPLER ACOUSTIC RADAR
by Dr. S.C. Kot, Department of Mechanical Engineering, The Hong Kong University of Science and Technology

APPLICATION OF FUZZY LOGIC AND EXPERT SYSTEMS IN METEOROLOGY
by Dr. Y. Leung, Department of Geography, The Chinese University of Hong Kong

Special Topics Lecture Series

Venue: Royal Observatory, Hong Kong
Date: 21 March, 1992
Subject: Chinese Programme on Climate and Environmental Research and Some New Results

Prof. Zeng Qingcun, Director of the Institute of Atmospheric Physics, Chinese Academy of Sciences, in Hong Kong attending the South China Oceanography Workshop at The Hong Kong University of Science and Technology, talked to members about the Chinese climate and atmospheric research programmes and shared some new results arising from the research. Prof. Zeng has extensive experience in the field of atmospheric and oceanographic research and the Society was grateful to him for agreeing to spare some time from his busy schedule to give this special lecture which was organized in
conjunction with The Hong Kong University of Science and Technology, the host for the Workshop.

Prof. Zeng gave a comprehensive review of the main thrust of research in China including programmes on the Dynamics and Prediction Theories of Climate, and the Detection and Prediction of Environment Change for the Coming 20 to 50 Years. He also presented results showing the improvements which have been made to both atmospheric and oceanographic GCMs in China over the past 10 years and some simulations of monsoon patterns and ENSO events using the models.
Calendar of Coming Events

This section is intended for the publication of forthcoming events organized by the Society or by other organizations with similar aims. If members wish to notify the Society of any such events they should mail or fax such information to the Editor-in-chief along with their name(s) and membership number(s).

1992

Lampeter, Wales, UK, September 3 - 5
Association of British Climatologists Summer Meeting on "Precipitation - Causes, Characteristics and Consequences".

Hong Kong, September 7 - 10
2nd International Conference of the Hong Kong Meteorological Society on "East Asia and Western Pacific Meteorology and Climate".

Hamburg, Germany, September 7 - 11
2nd International Conference on "Modelling of Global Climate Change and Variability".

Whistler, BC, Canada, September 15 - 18
4th American Meteorological Society Workshop on "Operational Meteorology".

Guildford, England, UK, September 21 - 23
Institute of Mathematics and its Applications Conference on "Stably Stratified Flows: Flow and Dispersion over Topography".

Sao Paulo, Brazil, September 28 - October 2
7th Brazilian Meteorological Congress on "Climate Change and the Environment".

Portland, OR, USA, September 29 - October 2
3rd American Meteorological Society Conference on "Polar Meteorology and Oceanography".

6th American Meteorological Society Conference on "Mountain Meteorology".

Huangshan City, China, October 5 - 9
International Symposium on "Turbulence and Diffusion".

Davos, Switzerland, October 11 - 16
WMO/SMU/AMS International Conference on "Mountain Environments and Changing Climates".

Victoria, BC, Canada, October 13 - 16
International Symposium on "Climate Change and Northern Fish Populations".

Reno, NV, USA, November 1 - 5
28th American Water Resources Association Annual Conference and Symposia on "Managing Water Resources during Global Change".

Nairobi, Kenya, December 7 - 11
1st International Conference of the African Meteorological Society.

Jerusalem, Israel, December 28 - 31
Yale Mintz Memorial Symposium on "Climate and Climate Change".
1993

Anaheim, CA, USA, January 17 - 22
73rd American Meteorological Society Meeting.
4th American Meteorological Society Symposium on "Global Change Studies".
8th American Meteorological Society Conference on "Applied Climatology".
8th American Meteorological Society Symposium on "Meteorological Observations and Instrumentation".
9th American Meteorological Society International Conference on "Interactive Information and Processing Systems for Meteorology, Oceanography and Hydrology".
American Meteorological Society Conference on "Land-surface/Atmospheric Interactions on Global and Regional Scales".
American Meteorological Society Symposium on "Challenges in Atmospheric and Earth Sciences".
New Delhi, India, January
International Conference on "Sustainable Development Strategies and Global/Regional/Local Impacts on Atmospheric Composition and Climate".

Monterrey, Mexico, February 23 - 25
International Conference on "Air Pollution".
Hong Kong, March
4th Hong Kong Meteorological Society Annual Meeting.
Santiago, Chile, March
Summer School, Workshop and Field Experiment on "Urban Climatology and Air Pollution".

Hobart, Australia, March 29 - April 2
4th International Conference on "Southern Hemisphere Meteorology and Oceanography".
Atlanta, GA, USA, April 6 - 10
89th Annual Meeting of the Association of American Geographers.
Beijing, China, May 26 - 29
International Symposium on "Natural Disasters and Agricultural Strategies".

Fredericton, NB, Canada, June 7 - 11
27th Annual Congress of the Canadian Meteorological and Oceanographic Society (CMOS).
Yokohama, Japan, July 11 - 23
4th Scientific Assembly of the International Association of Hydrological Sciences (IAHS).

4th Scientific Assembly of the International Association of Meteorology and Atmospheric Physics (IAMAP).
Calgary, AL, Canada, September 12 - 18
13th International Congress of Biometeorology.

1994

Hong Kong, March
5th Hong Kong Meteorological Society Annual Meeting.
San Francisco, CA, USA April 2 - 6
90th Annual Meeting of the Association of American Geographers.
The Hague, Netherlands, August 4 - 10
28th Congress of the International Geographical Union.
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